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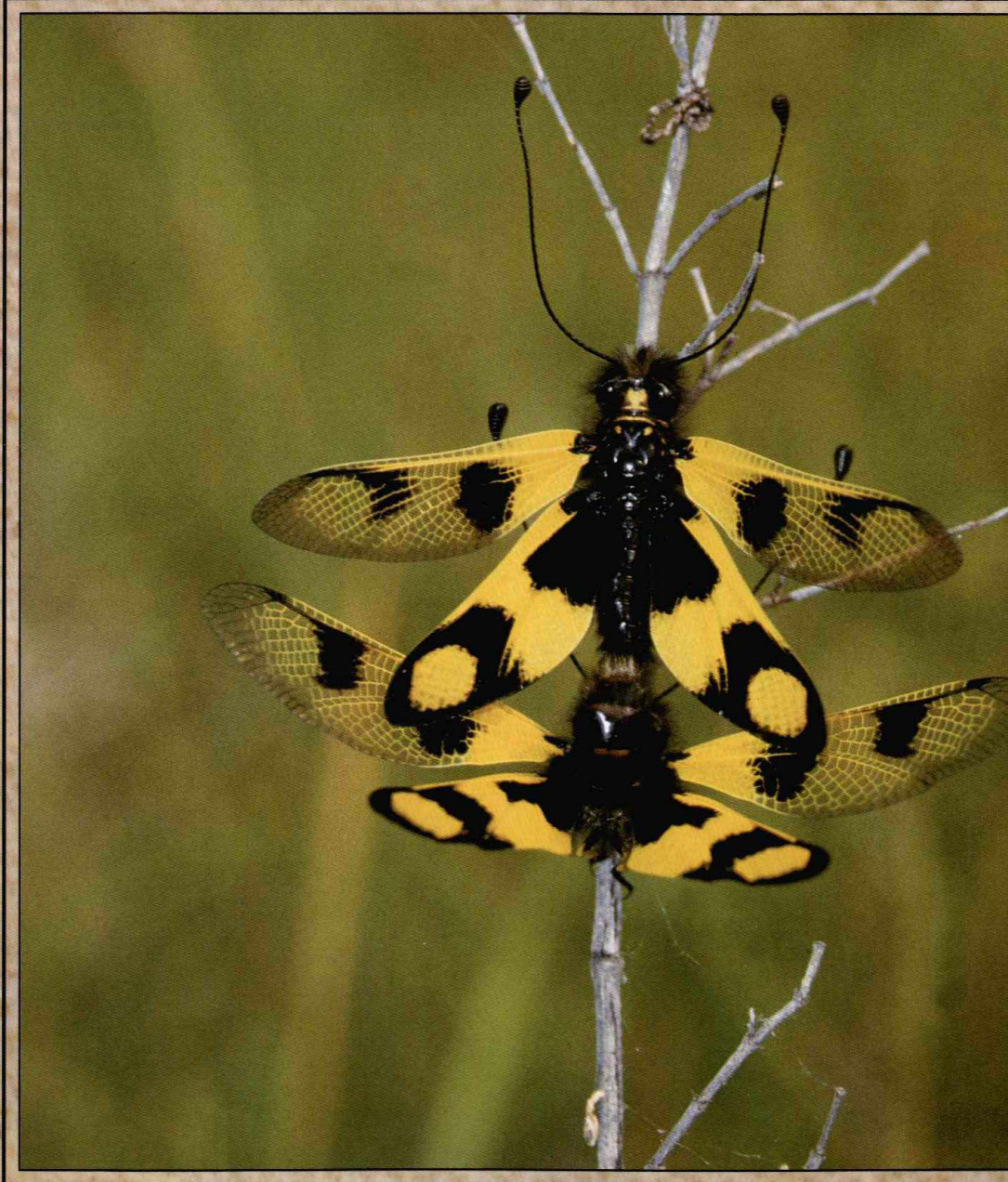

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FLORA IN VEGETACIJA

FLORA E VEGETAZIONE

FLORA AND VEGETATION

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FLORA IN VEGETACIJA INTENZIVNO RABLJENIH NJIV OSREDNJE GORENJSKE

Klemen ELER & Franc BATIČ
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IZVLEČEK

Raziskava prikazuje stanje plevelne flore in vegetacije na intenzivno rabljenih njivah Kranjskega in Sorškega polja. Ob uporabi standardne Braun-Blanquetove fitocenološke metode popisovanja in metod združevanja v skupine se kaže velika osiromašenost plevelnih sestojev ne glede na kulturo ali tip kolobarja. V sestojih manjkajo številne ogrožene plevelne vrste, pa tudi take, ki drugje v Sloveniji še niso redke. Zaradi pomanjkanja značilnic večine sinsistematskih enot je uvrščanje sestojev v združbe izredno težavno; izjema pri tem niso niti sestoji strnišč in žitnih njiv. Kažejo se fragmenti treh plevelnih združb: Oxalido-Chenopodietum polyspermi *R. Tx. 1950,* Setario-Galinsogetum parviflorae *R. Tx. 50 em Th. Mueller et Oberd. 1983 in* Aphano-Matricarietum chamomillae *R. Tx. 1937, od katerih je predvsem zadnja videti najbolj ogrožena. Ob nadaljevanju intenzifikacije pridelave, širjenja silažne koruze in opuščanja žit v kolobarju bodo v kratkem potrebni ukrepi varovanja plevelne flore.*

Ključne besede: plevelna vegetacija, plevelne združbe, intenzivno poljedelstvo, Gorenjska, Slovenija

FLORA E VEGETAZIONE IN CAMPI A LAVORAZIONE INTENSIVA NELLA CARNIOLA CENTRALE

SINTESI

Il lavoro illustra lo stato della flora e della vegetazione segetale in campi a lavorazione intensiva nelle regioni del Kranjsko e Sorško polje. Grazie al metodo fitocenologico standard di Braun-Blanquet per l'inventario e ai metodi di raggruppamento è emerso l'impoverimento delle componenti segetali, a prescindere dalla coltura o dal tipo di rotazione. Vengono a mancare diverse specie segetali minacciate come pure specie che in altre zone della Slovenia non vengono ancora considerate rare. A causa della mancanza delle particolarità di gran parte delle unità sinsistematiche, l'inserimento delle componenti in associazioni si è rivelato estremamente difficile anche per le componenti dei campi di cereali e stoppie. Gli autori hanno identificato i frammenti di tre associazioni segetali: Oxalido-Chenopodietum polyspermi *R. Tx. 1950,* Setario-Galinsogetum parviflorae *R. Tx. 50 em Th. Mueller et Oberd. 1983 e* Aphano-Matricarietum chamomillae *R. Tx. 1937, quest'ultima è la più minacciata. Con l'intensificarsi della coltivazione, la diffusione del mais conservato in silos e l'abbandono dei cereali nella rotazione si renderanno necessarie misure di tutela della flora segetale.*

Parole chiave: vegetazione segetale, associazione vegetale, coltivazione intensiva, Carniola, Slovenia

UVOD

Intenzivnost poljedelske pridelave ima močan vpliv na plevelno floro in vegetacijo določenega območja. Z rednimi in učinkovitimi ukrepi mehaničnega in kemičnega zatiranja, s temeljito obdelavo tal, z uporabo organskih in mineralnih gnojil, s setvijo kvalitetnega in prečiščenega semena visokoproduktivnih sort ter z različnimi ukrepi agromelioracij človek vpliva v našem podnebju na plevele in plevelne združbe bolj kot kateri koli pedoklimatski dejavnik rastišča. Optimalizacija pridelave zmanjšuje variabilnost rastišč in s tem variabilnost plevelne flore, tako da uspevajo le redke rastlinske vrste. Gorenjska regija je s tega vidika ogrožena morda še bolj, saj je poljedelska pridelava večinoma podrejena živinoreji; služi namreč zagotavljanju potreb po krmi, pri čemer ima izreden pomen silažna koruza.

Namen raziskave je opozoriti na izgubljanje pestrosti plevelne flore, ki jo neizogibno prinese intenzifikacija poljedelstva. Zasnova raziskave je takšna, da nam lahko pokaže le trenutno stanje vegetacije za obravnavano območje, ne pa celostnega procesa spreminjanja. Sloni na temeljnih fitocenoloških in botaničnih metodah dela, kljub temu da so te metode za tako hitro spreminjajoči se tip vegetacije nekoliko manj primerne.

Spremembe v plevelni vegetaciji in flori so preučevali nekateri domači in tuji raziskovalci (Holzner, 1978; Kojić, 1985; Ries, 1991; Hilbig & Bachthaler, 1992a, 1992b; Kaligarič, 1993; Lešnik, 1995, 1997, 2001). Ker so razmere za uspevanje plevelov bolj ali manj podobne tistim v drugih deželah srednje Evrope, je smiselno pričakovati plevelne združbe, ki jih navajajo npr. Oberdorfer (1957), Mucina (1993), Mochnacký (2000) *idr.* Združbe, ki jih navajajo avtorji iz mediteranskih in submediteranskih območij (Kaligarič, 1995, 2001; Poldini *et al.*, 1998), so vrstno že precej bogatejše (številne termofilne plevelne vrste), prav tako tudi združbe panonske nižine niso primerljive s sestoji preučevanega območja.

OBMOČJE RAZISKAVE

Lokacije popisovanja sodijo geografsko v Sorško in Kranjsko polje, ki sta pretežno ravninski regiji na nadmorski višini od 350 do 400 m. Geološka sestava je razmeroma preprosta – večinoma jo gradijo karbonatni sedimenti, ki se jim ponekod pridružijo glina, melj ali lapor. Območje je v dobršnem delu v kmetijski rabi – njive, travniki, pašniki. Gozdovi se razprostirajo na slabših, nekoliko zakisanih in izpranih tleh (konglomeratna podlaga) in sodijo v združbi *Vaccinio myrtilli-Carpinetum betuli* in *Vaccinio myrtilli-Pinetum sylvestris.*

Podnebje je po Klimatografiji Slovenije (1992) zmerno celinsko s povprečno letno temperaturo 8,3 °C, povprečno januarsko -2,3 °C, povprečno julijsko 18,5 °C ter povprečno temperaturo v vegetacijski dobi 14,7 °C. Povprečno pade nekaj pod 1400 mm padavin letno, pri čemer so velika nihanja med leti (od 990 do 1770 mm) in tudi znotraj leta. Število sončnih ur je v povprečju 1780 ur letno, število dni s snežno odejo pa 66 dni.

Natančnejše lokacije in termini popisovanja so naslednji (glej Tab. 1):

- Labore (Sorško polje): 21. april 2001 (strnišče) – št. 18; 18. junij 2001 (koruza) – št. 10; 11. avgust 2001 (koruza) – št. 9; 6. junij 2002 (žito) – št. 12;
- Zlato polje (severno od Kranja): 17. junij 2001 (čebula) – št. 4; 11. avgust 2001 (čebula) – št. 3; 6. junij 2002 (žito) – št. 5;
- Brnik (ob letališču): 21. april 2001 (žito) – št. 14; 18. junij 2001 (žito) – št. 17; 15. avgust 2001 (strnišče) – št. 16; 17. oktober 2001 (strnišče) – št. 15; 5. junij 2002 (žito) – št. 13;
- Lahovče (severno od ceste Lahovče-Vodice): 21. junij 2001 (krompir) – št. 8; 14. avgust 2001 (krompir) – št. 7; 8. junij 2002 (žito) – št. 6;
- Lahovče (južno od ceste Lahovče-Vodice): 21. junij 2001 (sladk. pesa) – št. 2; 14. avgust 2001 (pesa) – št. 1; 8. junij 2002 (žito) – št. 11.

MATERIAL IN METODE

Delo temelji na terenskih popisih, opravljenih po standardni Braun-Blanquetovi fitocenološki metodi z ocenjevanjem gostote in dominance vrst po kombinirani lestvici (Braun-Blanquet, 1964). Popisovali smo v obdobju dobrega leta (od aprila 2001 do junija 2002). Lokacije smo izbrali načrtno na podlagi poznavanja kmetijske rabe oz. intenzivnosti pridelovanja. Popisali smo pet njiv v lasti kmetijskega podjetja Mercator KŽK kmetijstvo Kranj, s tem da smo vsako njivo (lokacijo) popisali v petih terminih. V vsakem terminu smo na vsaki od lokacij ponovili popise na petih ploskvah v velikosti 400 m^2. Skupno je bilo opravljenih 87 popisov. Ker smo želeli preučiti vpliv poljščine, kolobarja in delno lastnosti tal, smo popisovali v naslednjih kulturah: v prvem letu v koruzi, žitu, sladkorni pesi, čebuli in krompirju, v drugem letu je povsod sledilo žito. Za nadaljnje izvrednotenje smo po pet popisov iste lokacije in istega termina združili v en sintetičen popis in tako naredili sintetično tabelo (Tab. 1). 18 tako dobljenih sintetičnih popisov smo primerjali po sorodnosti z metodami združevanja v skupine oz. hierarhičnega kopičenja, pri čemer smo za kriterij upoštevali zgolj zastopanost vrste, ne pa njene povprečne pokrovne vrednosti. Združevanje smo opravili s statističnim programskim paketom Statistica 5.0, kjer smo za metodo združevanja uporabili Wardovo metodo, za merjenje razdalj pa odstotno oddaljenost. Sintetične popise smo primerjali tudi po razmerjih med življenjskimi oblikami plevelov, pri čemer smo upoštevali tudi pokrovnost vrst, ki smo jo dobili z izračunom aritmetične sredine sred-

njih vrednosti pokrovnostnega razreda (Dierschke, 1994; Lešnik, 1995).

Nomenklaturo taksonov navajamo po Mali flori Slovenije (Martinčič *et al.*, 1999), nomenklaturo sintaksonov pa po Tüxenu (1950), kjer so združene segetalne in okopavinske združbe v en sam razred - *Stellarietea mediae*.

REZULTATI IN RAZPRAVA

Floristične značilnosti plevelnih sestojev

V celotnem obdobju raziskave je bilo ugotovljenih 128 rastlinskih vrst, od katerih jih kar 27% ne moremo šteti za tipično plevelne, saj izhajajo iz drugih fitocenoz oz. se na njivah pojavljajo le prehodno. Povprečno smo našli 14 vrst na popis, pri čemer so se za najrevnejše izkazali sestoji v žitu, če je to sledilo okopavini. Tam smo ponekod našli le 5 vrst na 400 m^2, kar kaže na velik negativni vpliv ozkega kolobarja. Nasprotno so strnišča dokaj bogata (do 49 vrst v spomladanskem strnišču), vendar je tudi v teh vrstna sestava zelo "običajna". Horološko prevladujejo mezofilni geoelementi: evropski, evrazijski, evrosibirski, paleotemperatni, pogosti so tudi kozmopoliti. Tudi povprečni Ellenbergov indeks za termofilnost, ki znaša 5,9, kaže, da gre za tipično srednjeevropsko nižinsko do gričevnato rastje. Najpogostejše vrste so naslednje: *Cirsium arvense, Calystegia sepium, Echinochloa crus-galii, Galium aparine, Viola arvensis, Polygonum aviculare, P. persicaria* in *Setaria viridis*.

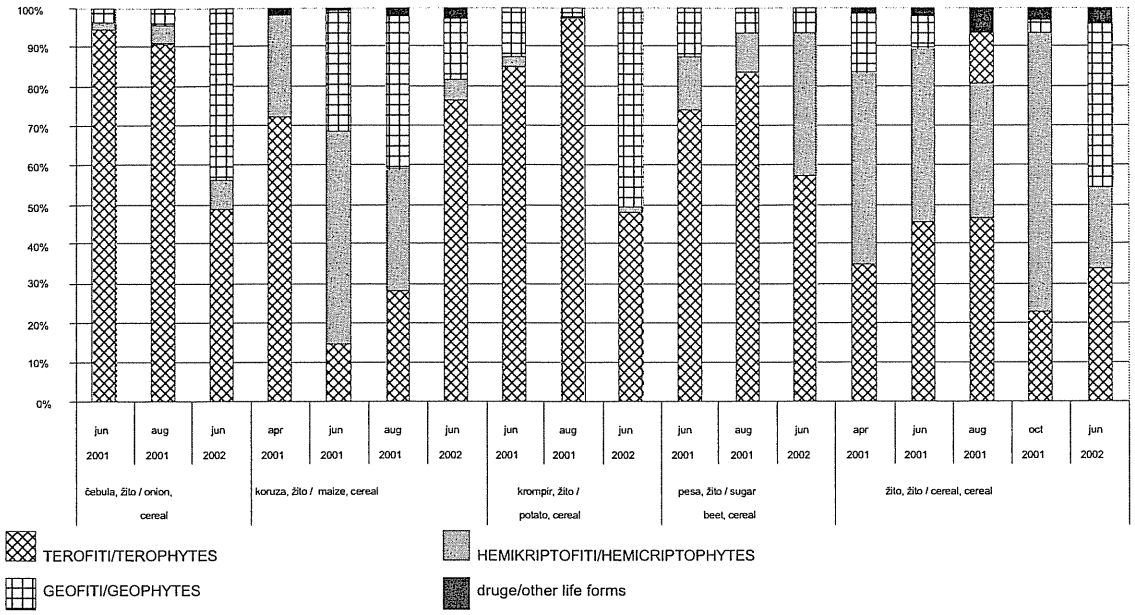
Značilna je popolna odsotnost nekaterih vrst, ki veljajo za ogrožene ali ranljive, našli nismo niti vrst, katerih pogostnost je sicer v upadanju, a v Sloveniji še niso tako redke. Tako ni bilo opaziti vrst kot *Papaver rhoeas, Legousia speculum-veneris, Ranunculus arvensis, Lolium temulentum, idr.* Nekatere od teh vrst so bile na obravnavanem območju sicer opažene, vendar so se umaknile na različna ruderalna rastišča – nasipališča, mesta ob cestah in poteh, deponije, ozare *idr.*

Ker številni avtorji (npr. Kovačević, 1979; Jogan, 2000; Lešnik, 2001) poudarjajo vse večji pomen neofitskih plevelnih vrst, smo se v določeni meri posvetili tudi pogostosti pojavljanja teh vrst. Ob primerjavi z drugimi podobnimi raziskavami lahko rečemo, da je pomen neofitov na območju raziskave manjši kot v drugih, toplejših območjih Slovenije. Kot zelo pogosta in gospodarsko škodljiva se kaže le vrsta *Amaranthus retroflexus*, našli pa smo še naslednje: *Chamomilla recutita, C. suaveolens, Conyza canadensis, Veronica persica, Abutilon theophrasti, Galinsoga parviflora* in *Panicum capillare*. Številnih, drugje po Sloveniji vse bolj škodljivih vrst nismo odkrili (npr. *Sorghum halepense, Ambrosia artemisiifolia, Xanthium italicum, Cyperus esculentus, Datura stramonium).* Od arheofitov so zelo pogoste prosaste trave rodov *Echinochloa, Digitaria, Panicum* in *Setaria*, razmeroma pogosta arheofitska vrsta je tudi *Solanum nigrum*. Arheofitov, ki so vezani na slabo očiščeni semenski material, večinoma nismo zasledili. Sem sodijo vrste, ki jih prištevamo med najbolj ogrožene: *Agrostemma githago, Centaurea cyanus, Lolium temulentum, Buglossoides arvensis, Vaccaria pyramidalis, Adonis* sp.

Analiza življenjskih oblik plevelov

Razmerja med posameznimi življenjskimi oblikami se z intenzifikacijo poljedelstva značilno spreminjajo. Na to kažejo raziskave domačih in tujih raziskovalcev (Kojić, 1985; Hilbig & Bachthaler, 1992a, 1992b; Lešnik, 1995, 1997, 2001). Delež v pokrovnosti terofitov se značilno povečuje, pri čemer so zlasti uspešne kozmopolitske vrste z drobnimi in številnimi semeni, ki pogosto kažejo pravo ali navidezno odpornost proti herbicidom *(Chenopodium album, C. polyspermum, Polygonum pericaria, Setaria viridis, Echinochloa crus-galii, Solanum nigrum*, idr.). Od geofitov močno napredujejo tisti s korenikami *(Calystegia sepium, Convolvulus arvensis, Elytrigia repens),* ki se pri mehaničnih pa tudi kemičnih ukrepih zatiranja hitro regenerirajo; nasprotno pa geofiti z gomolji in čebulicami hitro izginejo (npr. *Gagea pratensis, G. villosa, Ornithogallum umbellatum, Allium* sp.). Značilno je tudi splošno zmanjšanje pokrovnosti in pojavljanja hemikriptofitov, čeprav so med njimi vrste, katerih pomen se v intenzivnem poljedelstvu poveča, saj imajo večinoma mesnate, debele podzemne organe in s tem več zalog hrane za regeneracijo nadzemnih delov *(Cirsium arvense, Symphytum officinale, Rumex obtusifolius in R. crispus).*

V raziskavi je bilo od pravih plevelnih vrst skupno ugotovljenih 53% terofitskih, 37% hemikriptofitskih in 6% geofitskih plevelnih vrst. Glede na termin popisovanja in lokacijo oz. kulturno rastlino so deleži v relativni pokrovnosti med življenjskimi oblikami zelo različni (Sl. 1). Opazna je prevlada terofitov v okopavinah nižje rasti (krompir, čebula, pesa), druge življenjske oblike so tam malo pomembne. V žitu ostajajo hemikriptofiti nekoliko pogostejši, pokrovnost terofitov pa je v primerjavi s sestoji v okopavinah precej manjša. V koruzi v poletnem času bode v oči zelo nizek delež pokrovnosti terofitov, pomembni so geofiti in hemikriptofiti, kjer pa gre predvsem za tri vrste – *Calystegia sepium, Convolvulus arvensis in Cirsium arvense*. Prvi dve sta uspešni tudi zaradi ovijanja okoli stebel koruze, s čimer prihajata do svetlobe.



Sl. 1: Razmerja v pokrovnosti življenjskih oblik plevelov po terminih in lokacijah (kulturah).
Fig. 1: Relationships between coverages of weed life forms within terms and locations of relevés.

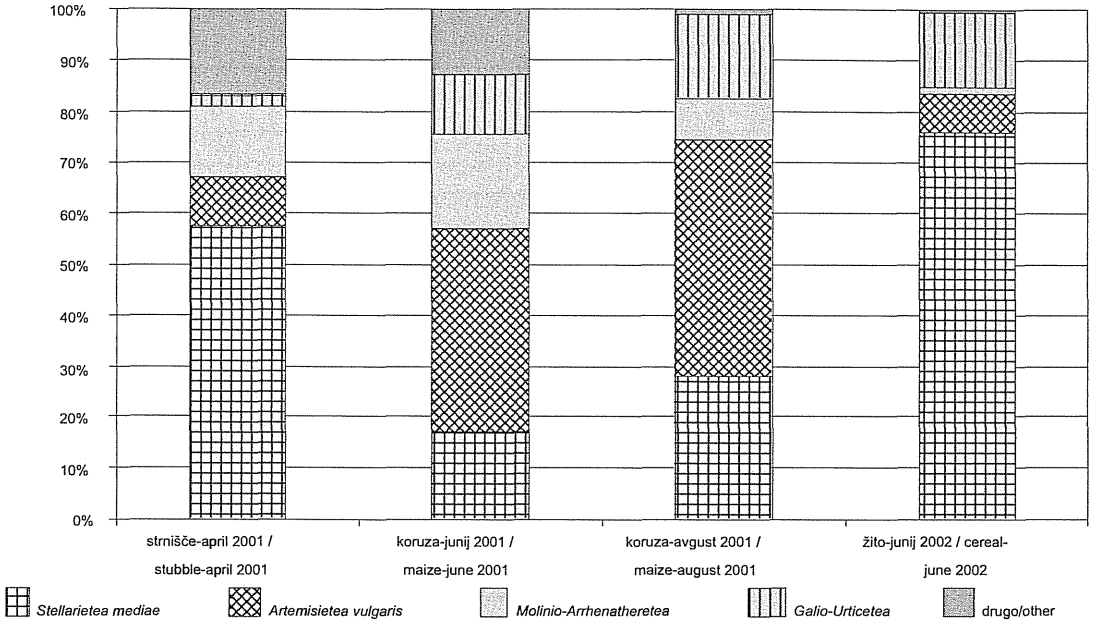
Sintaksonomska opredelitev sestojev

Zaradi velike osiromašenosti plevelnih sestojev le-te težko uvrstimo v združbe. Večinoma se kažejo le fragmenti združb, neredko pa ni mogoče razpoznati niti teh. V fitocenološki tabeli (Tab. 1) so provizorično ti fragmenti vendarle prikazani s pravokotniki. Kljub za gorenjske razmere velikemu deležu žita v kolobarju je najbolj ogrožena prav segetalna združba *Aphano-Matricarietum chamomillae* R. Tx. 37. V večini popisov ni bilo značilnic združbe *(Aphanes arvensis in Chamomilla recutita),* še redkejše so bile značilnice zveze *Aperion spicae-venti* R.Tx. 50, od katerih smo našli v sledeh le vrste *Scleranthus annuus, Apera spica-venti* in *Anthemis arvensis.* Značilnice te pa tudi drugih zvez so v plevelnih sestojih nasploh redke, o čemer poročajo tudi drugi avtorji (npr. Lešnik, 1995, 1997). Pogosto gre za plevelne vrste nekoliko bolj ekstenzivno rabljenih površin – manj intenzivna obdelava tal, zelo kisla tla, večja vlažnost tal. Tudi na lokaciji na Brniku, kjer zaradi slabših tal v kolobarju prevladujejo žita, ni združba *Aphano-Matricarietum chamomillae* nič bolj značilna. Vzroki za posebno veliko ogroženost te združbe so številni in med seboj povezani: čiščenje semenskega materiala, globoka obdelava tal, kemično zatiranje, gost sklop žita, optimalizacija talnih razmer za veliko konkurenčnost žita. Pomladanske sestoje na strniščih (sintetični popis št. 5 iz Tabele 1), kjer nekaterih termofilnih enoletnic - značilnic še ni, lahko uvrstimo v samostojne združbe, lahko pa jih pojmujemo kot poseben aspekt združbe *Aphano-Matricarietum chamomillae.* Tem sestojem dajejo poseben pečat različne nizkorastoče prezimne enoletnice kot *Veronica hederifolia, V. arvensis, Sherardia arvensis, Aphanes arvensis, Viola arvensis, Cardamine hirsuta* in *Arabidopsis thaliana.* Plevelni sestoji v žitu so na lokacijah z ozkim kolobarjem včasih celo bolj okopavinski kot segetalni. Lešnik (2001) omenja te plevele v žitu pod skupnim pojmom združen okopavinski ostanek.

Plevelni sestoji v okopavinah nižje rasti (krompir, pesa, čebula) so laže opredeljivi, vendar predvsem v drugi polovici poletja, ko je treba ukrepe zatiranja opustiti. Zaradi redkega sklopa teh poljščin in razmeroma velike talne semenske banke se hitro izoblikujeta tipični srednjeevropski okopavinski združbi iz reda *Polygono-Chenopodiethalia* R. Tx., Lohm. & Prsg. 1950; to sta *Oxalido-Chenopodietum polyspermi* R. Tx. 1950 in *Setario-Galinsogetum parviflorae* R. Tx. 50 em Th. Mueller et Oberd. 1983. Mejo med tema združbama je pogosto težko potegniti, saj se ekološke zahteve značilnih vrst prekrivajo. Kljub temu je združba *Setario-Galinsogetum parviflorae* nekoliko bolj toploljubna in je na osenčenih ali na bolj vlažnih legah ne gre pričakovati v tipični obliki. Značilnice zveze *Polygono-Chenopodion polyspermi* Koch 1926 em. Siss. 1946, kamor uvrščamo združbo *Oxalido-Chenopodietum polyspermi,* so razmeroma dobro zastopane, saj gre za vrste, ki so dobro prilagojene intenzivni pridelavi, značilnice zveze *Panico-Setarion* Sissingh 1946 pa so bile razmeroma redke, kljub temu da gre za vrste z veliko ekološko plastičnostjo.

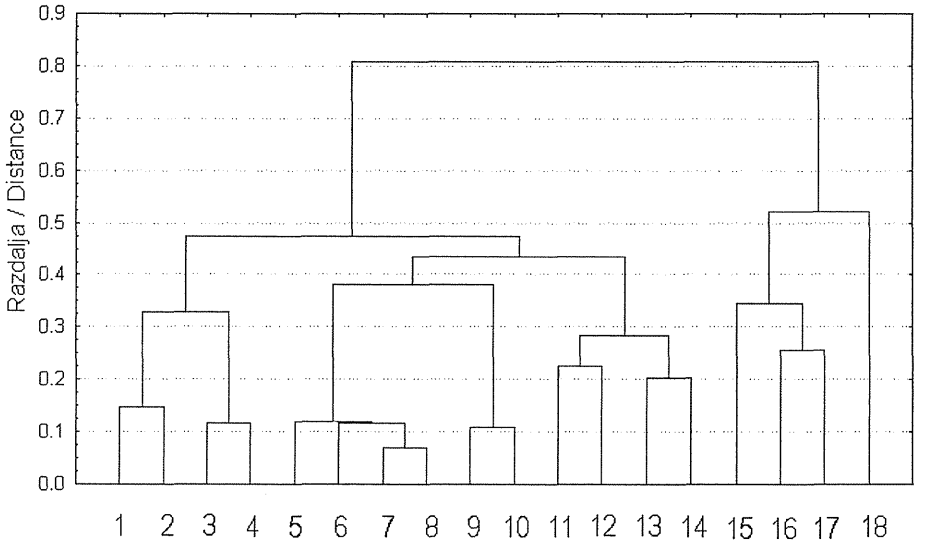
Plevelne sestoje v koruzi je večinoma nemogoče oz. nesmiselno uvrščati v katero od združb. Zaradi velike osenčenosti tal so terofitske plevelne vrste iz sintaksonomsko pomembnega razreda *Stellarietea mediae* redke tako po številu kot po pokrovnosti; večinoma jih

najdemo le še na robovih njiv. Močno se poveča relativna pokrovnost vrst iz drugih sintaksonomskih razredov, predvsem iz *Artemisietea vulgaris* Lohm., Prsg. et Tx. in Tx. 50 *(Convolvulus arvensis, Elytrigia repens in Cirsium arvense)* in *Galio-Urticetea* Th. Muell. in Oberd. 83 *(Calystegia sepium)*. Spremembe v relativni pokrovnosti vrst iz sintaksonomskih razredov na strnišču, v koruzi in naslednje leto v žitu kaže Sl. 2. V dendrogramu iz Sl. 3 vidimo dva šopa: v enem so plevelni sestoji strnišč in bolj ekstenzivnih žitnih njiv (popisi št. 15-18), v drugem pa sestoji okopavinskih njiv in njiv z žiti, če je uporabljen kolobar ozek oz. če v njem prevladujejo okopavine.



***Sl. 2: Deleži pokrovnosti vrst posameznih sintaksonomskih razredov po terminih popisovanja na njivi na Laborah. Legenda/Legend: SM** – Stellarietea mediae, **AV** – Artemisietea vulgaris, **MA** – Molinio-Arrhenatheretea, **GU** – Galio-Urticetea.*

Fig. 2: Percentages of weed coverage of sintaxa classes according to the time of relevé in the field at Labore (Kranj).



Sl. 3: Dendrogram plevelnih sestojev obravnavanega območja (glej Tabelo 1).
Fig. 3: Dendrogram of the weed stands in the investigated area (see Table 1).

Tab. 1: Sintetična fitocenološka tabela plevelnih sestojev na območju raziskave. Popisi 1-14 kažejo fragmente združb *Oxalido-Chenopodietum polyspermi* ***in*** *Setario-Galinsogetum parviflorae,* ***popisi 15-18 (sestoji strnišč, nekatere žitne njive) pa so bližji združbi*** *Aphano-Matricarietum chamomillae.*

Tab. 1: Synoptic phytocoenological table of weed stands in the investigated area. Relevés No. 1-14 show fragments of associations *Oxalido-Chenopodietum polyspermi* ***and*** *Setario-Galinsogetum parviflorae.* ***Relevés No. 15-18 (stubble stands, some cereal field stands) are closer to association*** *Aphano-Matricarietum chamomillae.*

	Zaporedna številka / No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	št. popisov / number of relevés	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	5	5	5
	št. vrst / number of species	33	34	38	31	16	18	14	19	27	23	23	30	29	25	51	45	54	52
MA	*Aphano-Matricarietum chamomillae* R. Tx. 1937																		
	Aphanes arvensis											II		I	II		I	I	III
	Chamomilla recutita			V	V	III													
OC	*Oxalido-Chenopodietum polyspermi* R. Tx. 1950																		
	Chenopodium polyspermum	V	I	IV		I	I	I		III						III	II		
	Oxalis fontana	I					I			I			I				I	II	II
SG	*Setario-Galinsogetum parviflorae* R. Tx. 50 em Th. Mueller et Oberd. 1983																		
	Setaria viridis	V	I	V		I	I	III	I	III		III	I	IV		V	V		
	Galinsoga parviflora			II	I					I									
AS	*Aperion spicae-venti* R. Tx.1950																		
	Apera spica-venti	I	I	I	II													II	
	Scleranthus annuus																		I
	Anthemis arvensis														III.				
PCP	*Polygono-Chenopodion polyspermi* Koch 1926 em. Siss. 1946																		
	Polygonum persicaria	III	III	V	III	II	I		I	II	II		V	III	I	III	IV	I	I
	Veronica persica		II	II	I							V	III	I	V	III	II	I	V
	Atriplex patula				II					I		II	II				I		I
	Anagallis arvensis												III			III	III	I	
	Geranium dissectum	I	I													III			
	Polygonum lapathifolium			III		II													
	Euphorbia helioscopia			I															
	Fumaria officinalis						I												
PS	*Panico-Setarion* Sissingh 1946																		
	Digitaria sanguinalis			III						II	I								
	Panicum capillare			I												III			
	Panicum miliaceum									I									
CC	*Centauretalia cyani* R. Tx., Lohm. & Prsg. 1950																		
	Viola arvensis	III	V	II	III	I	I		I			II	IV	IV	IV	III	IV	IV	V
	Fallopia convolvulus		I	IV	V	IV		I	II	V	I		IV	I			II		
	Sherardia arvensis												III		I		II		V
	Vicia hirsuta													II		III			
	Vicia villosa															III	I		
	Odontites vernus																	I	
PC	*Polygono-Chenopodietalia* R. Tx., Lohm. & Prsg. 1950																		
	Echinochloa crus-galli	IV	III	V	V	II	V	V	V	II	III	II					I	III	
	Chenopodium album	III	IV	II	III	I	IV	V	V	III						III	II	I	
	Amaranthus retroflexus	IV	II	III	II		I	IV	III	I									II
	Solanum nigrum	II	II				II	IV									II	I	
	Lamium purpureum	I	I	I	I							III							V
	Cardamine hirsuta														I	III			III
	Senecio vulgaris			I	III														
	Lamium amplexicaule											I							
	Sonchus oleraceus			I															
SM	*Stellarietea mediae* (Br.-Bl. 32), R. Tx., Lohm. & Prsg. 1950																		
	Polygonum aviculare	IV	IV	I	I	I	I	I	II	IV	III	II	V	III		III	II	II	IV

	Stellaria media		II	IV	I	I		I					V	II	I	I		II	II	V
	Capsella bursa-pastoris		I	V	V	IV		II		II			I	I					I	IV
	Matricaria perforata		II	III				I					I		I		V	III	IV	II
	Galeopsis tetrahit		II	II										I	III		V	IV	III	
	Mentha arvensis			I							III	II					III	I	I	
	Conyza canadensis		II	I	II	I											III			
	Brassica napus		II	III	V	IV				I										
	Aethusa cynapium				V	I	II							I						
	Myosotis arvensis			I															I	IV
	Veronica arvensis												II	III					I	
	Sonchus arvensis		II										I						I	
	Geranium molle													I						I
	Lathyrus tuberosus														II					
	Microrrhinum minus																		I	
	Veronica hederifolia																			III
	Sonchus asper			I																
	Cerinthe minor																			I
	Vicia sativa							I												
	Abutilon theophrasti		I																	
BT	*Bidentetea tripartitae* Tx., Lohm. et Prsg in Tx. 50																			
	Polygonum hydropiper			II									II		I					
	Bidens tripartita			I													III			
	Polygonum mite																		IV	
AV	*Artemisietea vulgaris* Lohm., Prsg. et Tx. in Tx. 50																			
	Cirsium arvense		IV	III	V	II	I		I	II	II	III	III	III	III	V	V	V	IV	III
	Convolvulus arvensis		I	I		I					III	IV	I	I	I			III	II	I
	Elytrigia repens		II	I	II	II	V				II	III		IV	II	I			II	
	Artemisia vulgaris							I	I	I						I	III		II	I
	Silene latifolia									I				I		I	III		I	V
	Erigeron annuus															I	III		I	III
	Linaria vulgaris										II	I						I		II
	Cirsium vulgare																III	I		
	Daucus carota															I	III			
	Lapsana communis																			II
MA	*Molinio-Arrhenathereta* Tx. 37																			
	Rumex obtusifolius										I	III		I		IV	III	II	II	IV
	Taraxacum officinale		I												I	II	III	I	I	V
	Agrostis stolonifera			III									I		I	I	V	III	I	
	Rorippa sylvestris				I	I					II	II					III			IV
	Dactylis glomerata										I	I		I			III			I
	Cerastium holosteoides															I	V	II	I	I
	Ranunculus repens														I	I	III	I	II	
	Potentilla reptans														I		III	I	I	
	Rumex crispus										II	II								I
	Achillea millefolium														I	I	III			
	Lysimachia vulgaris																III	I	II	
	Plantago lanceolata																III	II		I
	Poa pratensis												I						I	I
	Stachys palustris		II	I						I										
	Trifolium pratense													I				I	I	
	Euphorbia cyparissias																III	I		
	Galium mollugo																III			II
	Heracleum sphondylium		I											I						
	Lathyrus pratensis									I									I	
	Poa trivialis																		I	I

	Vicia cracca																I	II	
	Plantago intermedia					I													IV
	Lolium perenne										I								
	Holcus lanatus																		I
	Trifolium repens																		III
	Festuca pratensis																	I	
GU	*Galio-Urticetea* Th. Muell. in Oberd. 83																		
	Calystegia sepium		III	II	IV	II	IV	IV	II	II	IV	IV	II	III	IV		V	III	III	
	Galium aparine			IV	V	V	V	V	III	III			V			III			III	IV
	Rubus caesius										I	I		I	II		III	III	III	II
	Symphytum officinale				II	I	I					I		I				I	I	
	Eupatorium cannabinum														I		III	I	II	
	Urtica dioica		I																	I
	Aegopodium podagraria		I																	
	Galeopsis speciosa													I						
SS	*Sedo-Sclerantetea* Br.-Bl. 55 em. Th. Muell. 61																			
	Arabidopsis thaliana																			I
	Arenaria serpyllifolia																		I	
O	OSTALO																			
	Plantago major		I		II						I		I	I	I		III	I		II
	Hypericum perforatum				I										I	I	III	IV	I	I
	Tussilago farfara				I	I									I	I	III	I	I	
	Poa compressa			I								II	I				III			V
	Holcus mollis														I	I	V	I	II	
	Scrophularia nodosa								I	I							III		I	I
	Lolium multiflorum					I					II	II								II
	Poa annua				II							I				I				III
	Triticum aestivum				III	II											III			V
	Chamomilla suaveolens		I	I	II	IV														
	Solanum tuberosum										I	III		I						
	Verbascum nigrum																III	I		
	Astragalus glycyphyllos																	I	I	
	Equisetum arvense								I	I										
	Rubus fruticosus																III		I	
	Quercus robur											I								
	Arctium minus																			I
	Arctium sp.		I																	
	Festuca gigantea																		I	
	Populus nigra				I															
	Viola hirta																			I
	Veronica filiformis																III			
	Zea mays																III			
	Secale cereale														I					

ZAKLJUČEK

Rezultati kažejo na očitno osiromašenost plevelne flore in vegetacije obravnavanega območja. S tem se ujemata tako revna vrstna sestava sestojev kot težavnost uvrščanja sestojev v katero od združb. Osiromašenost je jasno razvidna ne glede na kulturno rastlino ali kolobar, uporabljen na določeni njivi, saj kljub rezultatom dendrograma (Sl. 3) tudi sestoji pretežno žitnih njiv niso vrstno veliko bogatejši. Združba, ki bi morala tam uspevati – *Aphano Matricarietum chamomillae* – je celo bolj okrnjena od obeh ugotovljenih okopavinskih združb. Posebno plevelni sestoji v koruzi, kjer sintaksonomsko pomembne vrste razreda *Stellarietea mediae* močno nazadujejo, kažejo na velik negativni vpliv te kulture na pestrost plevelne flore. Podatki so zaskrbljujoči, predvsem če upoštevamo, da se koruza v Sloveniji goji na 60% njiv; na Gorenjskem, kjer je delež živinorejskih kmetij še posebno velik, zavzema koruza še nekaj več površin.

Ker so bile lokacije popisovanja izbrane načrtno, to je s čim večjo stopnjo intenzivnosti pridelave, lahko ugotovljeno stanje pojmujemo kot skrajno podobo slovenske kulturne krajine, do katere pa bi dejansko lahko prišlo, če ne bodo prej sprejeti določeni ukrepi varovanja. Od teh omenja Kaligarič (1993, 1996, 2001) predvsem ohranjanje vzorčnih površin z ekstenzivnim načinom pridelave in vnašanjem ogroženih plevelnih vrst v posevke žit. V nekaterih srednjeevropskih državah se je za razmeroma uspešno pokazala tudi ekstenzifikacija robov večjih njiv. Zaradi velike razparceliranosti in počasnih ukrepov zložbe zemljišč ta strategija pri nas verjetno še ne bo kmalu uveljavljena.

FLORA AND VEGETATION IN THE INTENSIVE CROP PRODUCTION FIELDS OF THE CENTRAL GORENJSKA REGION

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SUMMARY

The research has shown a great weed flora impoverishment and difficulties in syntaxonomic classification of stands in intensively farmed fields of the Kranjsko and Sorško polje. Characteristic of such type of crop production are regular and radical measures taken to attain the best possible conditions for the growth of cultivated plants as well as to minimise production costs, which of course leads to a thorough selection of weed species. The work is based on phytocoenological survey (Braun-Blanquet method) carried out at different times of the study period (from April 2001 to June 2002) at various localities (in five crops with different types of rotation). The data are assembled in a synthetic phytocoenological table, which also serves as a basis for some other evaluations and processing (preparation of dendrogram). Weed vegetation with the following most frequently occurring species was prevalent: Cirsium arvense, Calystegia sepium, Echinochloa crus-galii, Galium aparine, Viola arvensis, Polygonum aviculare, Polygonum persicaria *and* Setaria viridis. *The numerous endangered as well as less endangered species were not recorded; these species are gradually withdrawing to the non-field habitats. As far as life forms are concerned, terophytes were prevalent, while in maize and cereals some geophytes with rhizomes were also significant.*

Fragments of the following associations were found: Oxalido-Chenopodietum polyspermi *R. Tx. 1950,* Setario-Galinsogetum parviflorae *R. Tx. 50 em Th. Mueller* et *Oberd. 1983 and* Aphano-Matricarietum chamomillae *R. Tx. 1937. The first two are root crop associations that occur mostly miscellaneously, while the third one is segetal and is floristically considered as the most impoverished association. In the association* Aphano-Matricarietum chamomillae, *its character species as well as character species of some higher synsystematic units, particularly the character species of the alliance were missing. In the dealt with area, this association has proved to be poorly preserved irrespective of the crop rotation width.*

If the intensification continues in Slovenia in direction as shown in this research, certain steps to protect the weed flora will have to be taken, the most effective among them probably being extensification of crop production, preservation of the existing primitive procedures of production, and extensification of the edges of large fields.

Key words: weed vegetation, weed communities, intensive crop production, Gorenjska, Slovenia

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RELATION BETWEEN ENVIRONMENTAL VARIABLES, SPECIES RICHNESS AND SPECIES COMPOSITION OF SLOVENIAN SEMI-DRY MEADOWS OF *MESOBROMION ERECTI* ALLIANCE

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ABSTRACT

Semi-dry meadows of the Central European alliance Mesobromion erecti *(class* Festuco-Brometea*) are habitats with high biodiversity. Our first aim was to recognize the variability of species composition of central, eastern, and southeastern Slovenian semi-dry grasslands. The second aim was to define which environmental variables affect to the greatest extent the species richness and species composition of those meadows. The vegetation was sampled using standard procedure of the Braun-Blanquet approach. From each plot the following soil parameters were measured: pH, humus, carbonates, potassium, phosphorus; some environmental variables were also estimated by the Ellenberg indicator values. Phytosociological relevés were classified by TWINSPAN. Five clusters were separated and their configuration checked in a CA–ordination. For the interpretation of floristical gradient, the environmental variables were correlated with the ordination axes using rank correlation test. It could be summarised that species richness is slightly positively affected by humus and nitrogen amounts. We could also conclude that soil parameters as pH, humus, carbonates, humidity and nitrogen contents are those environmental variables that mostly affect species composition of the Central Slovenian* Mesobromion *meadows.*

Key words: *Mesobromion erecti,* semi-dry meadows, species richness, classification, ordination, phytosociology, Ellenberg indicator values

RELAZIONE TRA VARIABILI AMBIENTALI, RICCHEZZA E COMPOSIZIONE DI SPECIE IN PRATERIE SEMIARIDE SLOVENE DELL'ALLEANZA *MESOBROMION ERECTI*

SINTESI

Le praterie semiaride dell'alleanza centro-europea Mesobromion erecti *(classe* Festuco-Brometea*) vengono considerate come habitat ad alta biodiversità. Scopo principale di tale studio è stato quello di riconoscere la variabilità della composizione di specie delle praterie semiaride in Slovenia centrale, orientale e sud-orientale. Lo scopo secondario invece era quello di definire quali variabili ambientali influenzano prevalentemente la ricchezza e la composizione di specie di tali praterie. Il campionamento della vegetazione è stato effettuato usando la procedura standard dell'approccio di Braun-Blanquet. In ciascuna delle aree sono stati rilevati i seguenti parametri: pH, humus, carbonati, potassio, fosforo; altre variabili ambientali sono state stimate attraverso l'indicatore di valori Ellenberg. I rilievi fitosociologici sono stati classificati con il TWINSPAN. Dalla classificazione sono emersi 5 cluster e la loro configurazione è stata verificata con l'ordinamento CA. Per l'interpretazione dei gradienti floristici le variabili ambientali sono state correlate con gli assi dell'ordinamento usando la correlazione di rango. Dai risultati ottenuti la ricchezza di specie risulta leggermente influenzata positivamente dall'humus e dalla quantità di azoto. La composizione di specie delle praterie di* Mesobromion *della Slovenia centrale, invece, si è rivelata influenzata in prevalenza da pH, humus, carbonati, umidità e contenuti di azoto.*

Parole chiave: *Mesobromion erecti,* praterie semiaride, ricchezza di specie, classificazione, ordinamento, fitosociologia, indicatore di valori Ellenberg

INTRODUCTION

The correlation between vegetation and environmental parameters is one of the most fundamental questions contributing to understanding plant species composition, structure in a particular habitat, landscape and region (Barbour *et al.*, 1987; Mucina, 1997). Although plant communities are dynamic entities undergoing continuous change in response to climate, land use patterns and intrinsic dynamics, understanding vegetation-environmental correlations at one point in time may help to predict possible shifts attributed to climate and land use changes (Burke, 2001).

Dry and semi-dry grasslands are one of the best-known vegetation types in Europe (Dierschke, 1997). Mostly they are of semi-natural origin (Ellenberg, 1996), *i.e.* they developed by forest grazing and clear-cutting (Pott, 1996) or after the abandonment of arable fields and vineyards (Schumacher *et al.*, 1995) and are maintained by various activities – mowing, grazing of domestic animals, cutting or burning of shrubs and trees (Kienzle, 1979; Pfadenhauer & Erz, 1980; Witschel, 1980).

In Slovenia, all secondary dry and semi-dry grasslands on basic, neutral and slightly acid soil on calcareous bedrock (limestone, dolomite, marl, flysch – a calcareous sandstone) under the tree line belong to the class *Festuco-Brometea* Br.-Bl. & R.Tx. ex Klika & Hadač 1944 em. Royer 1987 (Kaligarič, 1997a; Škornik, 2000). They are usually found in warm, sun-exposed areas. Those, in winter cold and in the summer extremely hot sites with shallow soil layer, often dry out completely through the action of wind and direct solar irradiation (Kierchner *et al.*, 1980; Vogel, 1981).

With about 700 vascular plants and 200 bryophytes and lichens, *Festuco-Brometea* grasslands are among the most species-rich habitats in Europe (Willems, 1990). In the last decades they have rapidly declined in their size and number in Central and Western Europe (Wolkinger & Plank, 1981) due to the changes in traditional land-use and extensive management (Horvat *et al.*, 1974; Willmans, 1975; Glavač *et al.*, 1979; Kinzel, 1983). The consequence is fragmentation and isolation of the remnant grasslands (Keymer & Leach, 1990). Other threat to this type of grasslands in Slovenia is their abandonment, where consequently secondary succession has changed many grasslands into scrub and forest (Kaligarič, 1997a, 1997b, 1998).

In Slovenia, vegetation of *Festuco-Brometea* class is quite clearly divided into two orders: the sub-Mediterranean-Illyrian order *Scorzoneretalia villosae* Horvatić 1975, which is distributed in the south-western (sub-Mediterranean) part of Slovenia (Kaligarič, 1997a), and the *Brometalia erecti* Koch 1926 order that presents continental dry and semi-dry grasslands, characterised by sub-Atlantic-sub-Mediterranean species (Mucina & Kolbek, 1993). *Brometalia erecti* order includes semi-dry and dry grasslands of western, central and southern Europe. This order is represented by four alliances (Dierschke, 1997). In Slovenia and in southern Europe, only alliance *Mesobromion erecti* (Br.-Bl. & Moor 1938) Oberdorfer 1957 can be found (Škornik, 2000). The *Mesobromion erecti* grasslands have slightly mesophilous character – they mostly appear on sites with deeper, moderate humid soil, with pH values around 7. Therefore they are often assigned as "semi-dry" or "semi-arid" grasslands ("Halbtrockenrasen"). As to floristic composition and synecology, this species-rich vegetation has an intermediate position between the extremely dry grasslands of the *Brometalia erecti* order, the acid grassland vegetation on nutrient-poor soils of the *Calluno-Ulicetea* class, and the mesophilous grassland vegetation of the *Arrhenatheretalia* order (Mucina & Kolbek, 1993).

Until now, only few qualitative descriptive studies of the *Brometalia erecti* vegetation in continental parts of Slovenia have been published (Tomažič, 1941, 1959; Petkovšek, 1970, 1974, 1977, 1978). The main objective of those studies was to describe the associations according to the Braun-Blanquet approach (Braun-Blanquet, 1964).

One of the major aims of the present work was to understand the variation in species composition and species richness of the central, eastern and south-eastern Slovenian semi-dry grasslands (*Mesobromion erecti* alliance) in ecological terms using field data and numerical methods.

MATERIAL AND METHODS

In the year 1999, 35 plots (size of 25 m^2) of semi-dry grasslands from the alliance *Mesobromion erecti* were selected in central, eastern and south-eastern Slovenia (Fig. 1). Vegetation on the plots was sampled using standard procedure of the Braun-Blanquet approach (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1973; Dierschke, 1994). Taxonomic nomenclature follows Martinčič *et al.* (1999) except for *Bromus erectus*. The following taxonomically complicated groups are presented as aggregates (agg.): *Bromus condensatus, B., erectus* and *B. transsylvanicus* as *Bromus erectus* agg., *Brachypodium pinnatum* and *B. rupestre* as *Brachypodium pinnatum* agg.; *Leucanthemum ircutianum* and *L. vulgare* as *Leucanthemum vulgare* agg.; *G. mollugo, G. lucidum* and *G. album* as *Galium mollugo* agg. All the grasslands are used as meadows, mown twice or at least once a year. Management exclude fertilisation, grazing or other treatments.

From each plot the following soil parameters were analysed: 1. pH (measured in 0.1 N solution of KCl by glass electrode), 2. humus (Walkey-Black method), 3. carbonates ($CaCO_3$) (volumetric by Scheibler calcio-

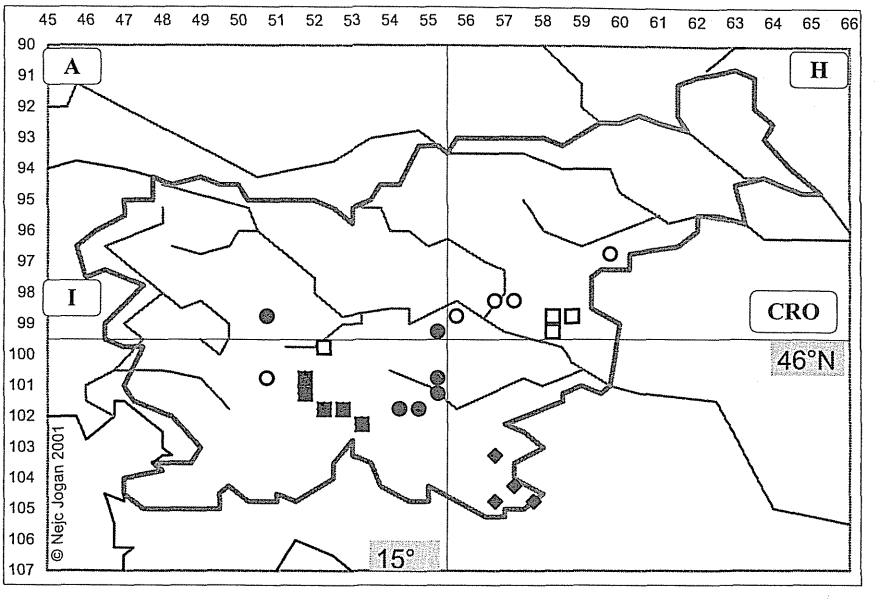


Fig. 1: Sampling plots distributed across central, eastern and south-eastern Slovenia. Legend: ◆ - 1st cluster, ○ - 2nd cluster, ● - 3rd cluster, □ - 4th cluster, ■ - 5th cluster.
Sl. 1: Vzorčišča v osrednji, vzhodni in jugovzhodni Sloveniji. Legenda: ◆ - 1. skupina, ○ - 2. skupina, ● - 3. skupina, □ - 4. skupina, ■ - 5. skupina.

metre), potassium (K_2O) (flame photometry), and phosphorus (P) (spectrophotometric measurements of the coloured complex). Some environmental variables were estimated by weighted (species frequencies are weights) averages of Ellenberg indicator values (Ellenberg *et al.*, 1991) for light, humidity, temperature and nitrogen content.

Species richness per 25 m^2 was defined for each plot.

For the numerical classification Two-Way-INdicator-SPecies-ANalysis (TWINSPAN; Hill, 1979) was applied. It was run using the computer program VEGI (Reiter, 1998). Correspondence Analysis (CA) was used to ordinate relevés (plots) using the computer package STATISTICA (Hirschfeld, 1935; Hill, 1973).

For the interpretation of gradients extracted from CA ordination the environmental variables and richness values were correlated with the ordination axes. All correlations were tested by Spearman's rank correlation test, which was carried out using non-parametric statistics in STATISTICA.

RESULTS AND DISCUSSION

Classification and ordination of the relevés

Phytosociological relevés of 35 plots are shown in Table 1. Sequence of the relevés is according to the TWINSPAN classification (Fig. 2). By classification procedure, five clusters with a size from 5-8 relevés (plots) were separated. For each cluster blocks of species, confirming slightly diverse species composition of the relevés, are shown in the table. Clusters do not represent phytogeographycally based units, nor management-dependent units. They entirely depend on ecological conditions, varying due to the soil characteristics. Cluster 1 includes 7 plots. Differential species of the cluster are *Agrostis capillaris, Festuca filiformis, Polygala vul-*

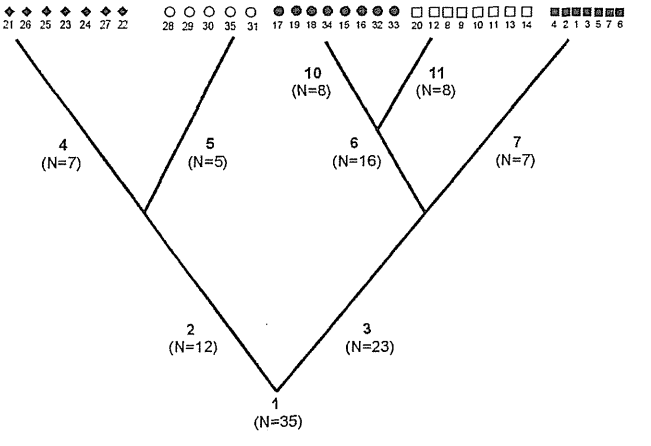


Fig. 2: TWINSPAN tree with 5end-clusters. The number of group and the number of plots (N) are shown for each node.
Sl. 2: TWINSPANOVO drevo s petimi skupinami. Št. skupine in št. popisov (N) sta prikazani za vsako presečišče.

garis, Carex pallescens and *Calluna vulgaris*, which are typical acidophilous species. The stands were mostly from Bela Krajina and occur on deeper, leached and slightly acid brown soils.

Cluster 2 with 5 plots has the following differential species: *Trisetum flavescens, Arrhenatherum elatius, Festuca pratensis, Lathyrus pratensis* and *Colchicum autumnale*. These species indicate more fertile and moist meadows, situated in different parts of central and eastern Slovenia (Fig. 1).

Cluster 3 and 4, with 8 plots each, are similar and without special differential species. They represent ecological situation "in between" the two poles.

Cluster 5 with 7 plots is differentiated with the group of basiphilous and termophilous species: *Carex humilis, Plantago holosteum, Polygala chamaebuxus, Gentiana verna subsp. tergestina, Knautia illyrica, Tragopogon tommasinii, Plantago argentea subsp. liburnica* and *Pseudolysimachion barrelieri. Pseudolysimachion barrelieri* subsp. *barrelieri*. Relevés presented in this cluster were collected from high Dinaric plateaus (Bloke, Menišija, Krim), where they occur on warm and dry sites with shallow and skeleton soil. Some species in this cluster are shared with cluster 4.

In the CA ordination, the 5 clusters appeared well-separated (Fig. 3). The first axis described 11.06%, the second 8.39%, the third 6.5% and the fourth 5.01% of the total variability. For the interpretation of the floristic gradients in sampled plots, only the most important ordination axis CA1 and CA2 were used.

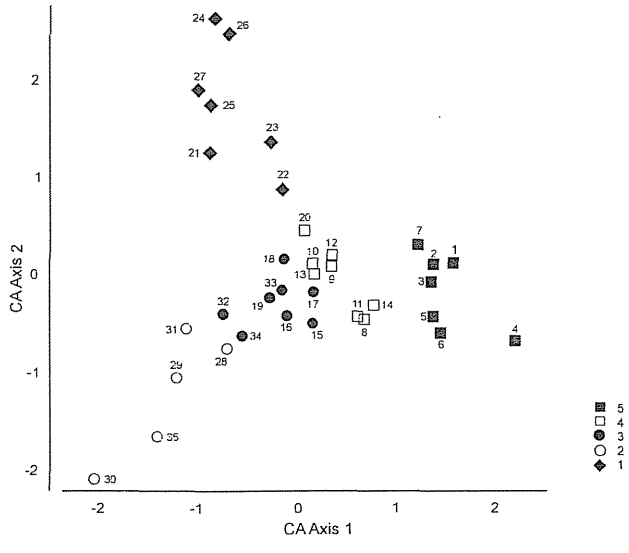


Fig. 3: CA (Correspondance Analysis) of Slovenian semi-dry grasslands** (Mesobromion erecti **alliance). 1-5 clusters defined by TWINSPAN are indicated.
Sl. 3: CA (Correspondence Analysis) ordinacija slovenskih polsuhih travišč (zveza** Mesobromion erecti**). Prikazane so skupine 1-5, določene s TWINSPAN analizo.

Environmental variables and species richness

Values of the measured and estimated environmental variables for 35 semi-dry grasslands stands are given in the Table 2. Values for calcite $CaCO_3$ vary a great deal - from totally decalcified leached soils as one extreme and to the soils very rich on $CaCO_3$ as the other. While some stands with the lowest values for $CaCO_3$ are also characterized by very low pH – they present stands on acid and leached soils on calcareous substrate (limestone, dolomite) from the central part of Dolenjska region and from Bela Krajina – some others may be decalcified, but not acidified. These relevés were collected on grasslands on deeper brown soils, which developed on marl and flysch. Phosphorous and potassium do not vary a great deal. Some plots have soil with higher humus content – they mostly represent stands on shallow and skeleton calcareous soil – rendzinas from high Dinaric plateaus. Ellenberg values do not vary so much as measured soil parameters.

Species richness per 25 m^2 was the lowest for the relevés in the 1st cluster due to the slightly acid and decalcified soil conditions. The highest species richness was established for the 5th cluster with stands from shallow rocky soils with basic conditions with a peak of 69 species.

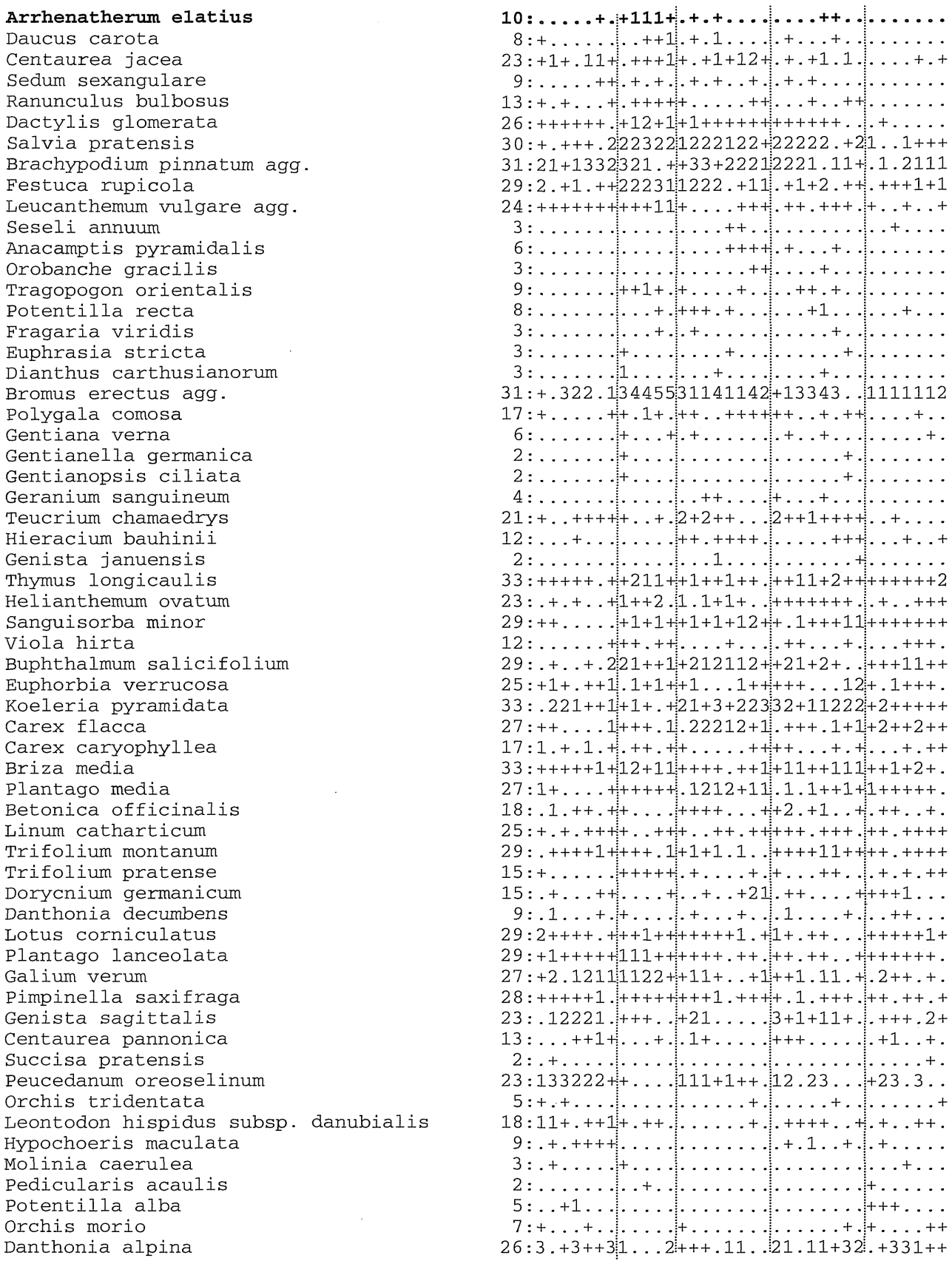
Correlations between environmental parameters, species richness and floristically based ordination

Before correlating floristically based gradients obtained from CA ordination with environmental parameters, the correlations among environmental variables were tested using Spearman's rank order correlation test. The Spearman rank order correlation coefficients (R) between single environmental variables were calculated. Some of the environmental variables were found to be significantly correlated (Table 3), *i.e.* CaCO3, which is positively correlated with pH, P, and K and negatively with humidity; pH is correlated with P and N values, *etc.* Species richness correlates positively with humus and nitrogen, which could be explained with natural fertility of the sampled meadows (fertilisation on plots were excluded).

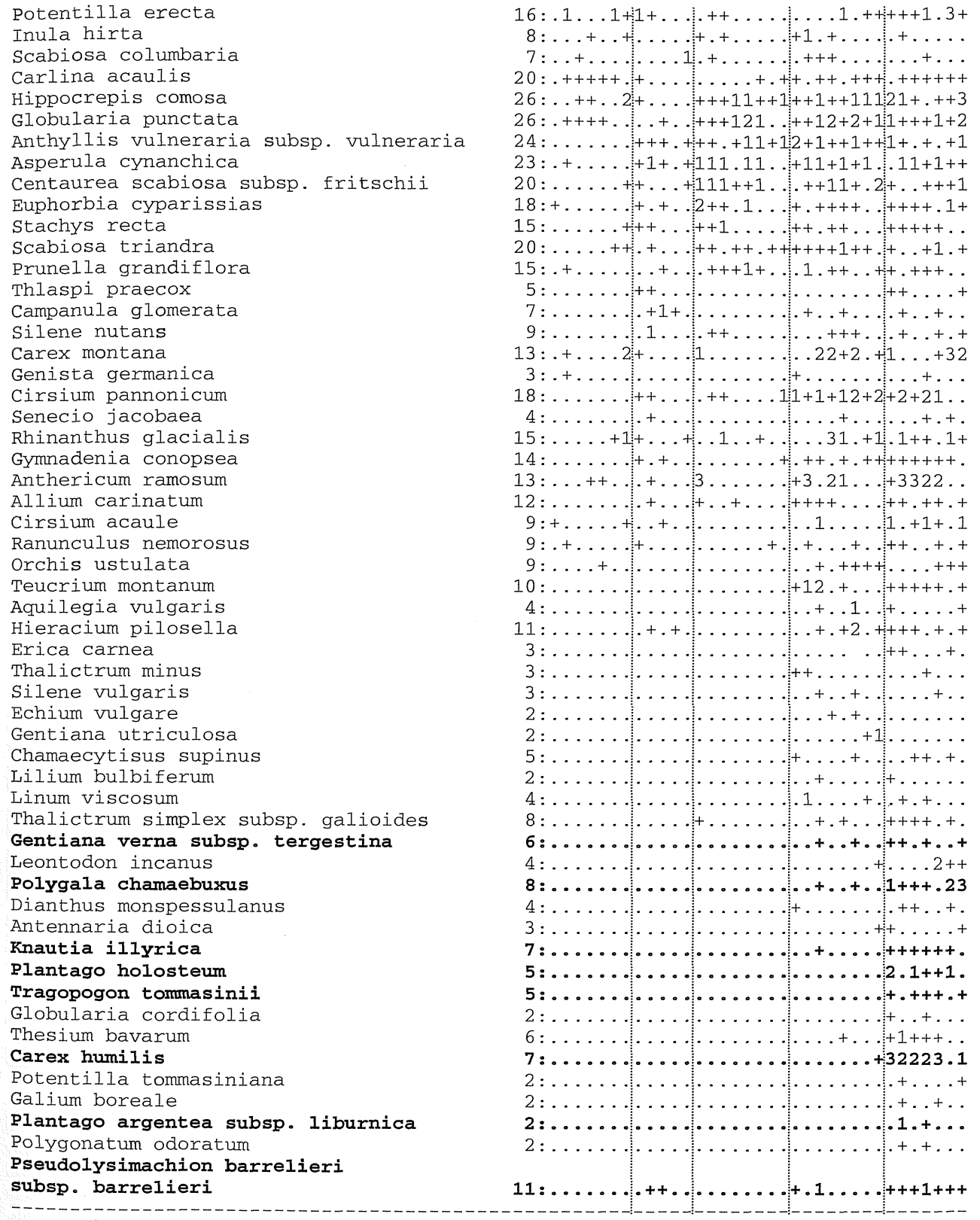
Finally, CA sample scores (coordinates) were correlated against all environmental variables, using Spearman's rank order correlation test (Tab. 4). Many of the environmental variables were found to be significantly correlated with CA sample scores. The first axis of the Correspondence Analysis (CA1) was found to be positively correlated with humus, $CaCO_3$ and K_2O, and negatively with humidity. It could be interpreted as a gradient from plots on deep and humid, decalcified brown soils to the plots on dry, shallow, calcareous soils. The second axis (CA2) was found to be strongly

Tab. 1: Phytosociological relevés of 35 Slovenian semi-dry grasslands** (Mesobromion erecti **alliance) classified by TWINSPAN. Species, characteristic for each cluster are indicated in the table.
Tab. 1: Fitosociološki popisi 35 slovenskih polsuhih travišč (zveza** Mesobromion erecti **alliace), klasificirani s TWINSPAN analizo. V tabeli so označene vrste, značilne za posamezno skupino.

	◆	○	●	□	■
Relevé number	22222222	22333111	31311332	10011111	00000000
	16534728	90517984	56230289	01344213	57676
Viola canina	4:.+..++.	.....	.....	.....	.....+.
Polygala vulgaris	**11:+++++++**	**...+.**	.....	.....	**.+...++**
Calluna vulgaris	**5:.2.++1+**	.....	.....	.....	.....
Veronica officinalis	3:.++..+.	.....	.....	.....	.....
Agrostis capillaris	**6:.21+1++**	.....	.....	.....	.....
Festuca filiformis	**6:211.2+1**	.....	.....	.....	.....
Carex pallescens	**6:.++++.++**	.....	.....	.....	.....
Rhinanthus minor	2:....++.	.....	.....	.....	.....
Prunella laciniata	12:++1++11	++..+	.....	+++	.....
Luzula campestris	7:+.+.+1.	+11..	.....	.....	.....
Carlina vulgaris	3:+.+....	.....	...1.	.....	.....
Ononis spinosa	2:.....+.	.....	..+..	.....	.....
Anthoxanthum odoratum	10:+.++.+.	1++.+	.....	...+.	.....+.
Filipendula vulgaris	20:3322+2+	+.2+.3	1+2+1+.+	2..1..	...+...
Cruciata glabra	14:.+..+++	+1++..	.++.....	...++.	..+...+..
Knautia arvensis	8:..+.+...	.111.	.+..++..	.....	.....
Achillea millefolium	9:.+...++	+++..	..+...+.	+.....	.....
Rumex acetosa	4:.....+.	+++..	.....	.....	.....
Holcus lanatus	7:++..+..	.++.+	.....	+.....	.....
Knautia drymeia	10:.++..+.	+.+.++	+..+..1.	....+.	.....
Primula vulgaris	3:+.....	...+.	.....	+.....	.....
Peucedanum cervaria	4:...+..+	.....	....+..	2.....	.....
Centaurium erythraea	2:+.....	....+	.....	.....	.....
Lathyrus pratensis	**3:.....**	**.++2.**	.....	.....	.....
Veronica chamaedrys	3:.....	.++.+	.....	.....	.....
Ranunculus acris	3:.....	.+++.	.....	.....	.....
Trifolium campestre	2:.....	.+..+	.....	.....	.....
Festuca pratensis	**3:.....**	**.+1+.**	.....	.....	.....
Poa angustifolia	2:.....	.++..	.....	.....	.....
Trisetum flavescens	**5:+.....**	**.+1++**	.....	.....	.....
Agrimonia eupatoria	3:.....	..++.	.....+	.....	.....
Prunella vulgaris	3:.....	..+++	.....	.....	.....
Convolvulus arvensis	2:.....	..++.	.....	.....	.....
Cynosurus cristatus	2:.....	..+.+	.....	.....	.....
Rhinanthus alectorolophus	2:.....	..++.	.....	.....	.....
Pastinaca sativa	2:.....	...++	.....	.....	.....
Galium mollugo agg.	9:.....	.++.++	.+++..+.	.+.....	.....
Vicia cracca	8:.....+	.+1++	.+.+..+.	.....	.....
Medicago falcata	5:.....	.++.1.	+..+....	.....	.....
Picris hieracioides	6:.....	..+.+.	+...++.	.....+.	.....
Veronica jacquinii	2:.....	.....	+..+....	.....	.....
Chrysopogon gryllus	3:.....	.....	1...33.	.....	.....
Aster amellus	2:.....	.....	...+1..	.....	.....
Clematis vitalba	2:.....	.....	.+...+.	.....	.....
Medicago lupulina	7:.....	+.+++.	+....+.	.....	.+.....
Colchicum autumnale	**5:.....**	**.++++.**	.....	.....+.	.....
Avenula pubescens	4:.....	.++1..	.....	+.....	.....
Hypericum perforatum	12:.+....	.+++++	++.+....	..+.+..	....+..



Arrhenatherum elatius 10:.....+.+111+.+.+....+....++..+.....
Daucus carota 8:+.....+.++1+.+.1....+...+..+.....
Centaurea jacea 23:+1+.11+.+++1+.+1+12+.+.+1.1.....+.+
Sedum sexangulare 9:.....++.+.+.+.+.+.+.+.+.+.....+.....
Ranunculus bulbosus 13:+.+...+.++++.....++...+..++.....
Dactylis glomerata 26:++++++.+12+1+1+++++++++++..+.....
Salvia pratensis 30:+.+++.222322122122+22222.+21..1+++
Brachypodium pinnatum agg. 31:21+1332321.+33+2221222 1.11+.1.2111
Festuca rupicola 29:2.+1.++22231222.+11.+1+2.++.+++1+1
Leucanthemum vulgare agg. 24:+++++++++11+....+++.++.+++.+..+..+
Seseli annuum 3:.....++.....+....
Anacamptis pyramidalis 6:.....++++.+...+.....
Orobanche gracilis 3:.....++.....+.....
Tragopogon orientalis 9:.....++1+.+....+..++.+.....
Potentilla recta 8:.....+.+++.+.....+1.....+...
Fragaria viridis 3:.....+.+.+.....+.....
Euphrasia stricta 3:.....+.....+.....+.....
Dianthus carthusianorum 3:.....1.....+.....+.....
Bromus erectus agg. 31:+.322.134455311411 42+13343..1111112
Polygala comosa 17:+.....++.1+.++..++++++..+.++....+..
Gentiana verna 6:.....+...+.+.....+..+.....+.
Gentianella germanica 2:.....+.....+.....
Gentianopsis ciliata 2:.....+.....+.....
Geranium sanguineum 4:.....++....+...+.....
Teucrium chamaedrys 21:+..++++..+.2+2++...2++1++++..+....
Hieracium bauhinii 12:...+.....++.++++.....+++...+..+
Genista januensis 2:.....1.....+.....
Thymus longicaulis 33:+++++.++211++1++1++.++11+2++++++2
Helianthemum ovatum 23:.+.+..+1++2.1.1+1+..+++++++.+..+++
Sanguisorba minor 29:++.....+1+1++1+1+12++.1+++11+++++++
Viola hirta 12:.....+++.++....+...++...+....+++.
Buphthalmum salicifolium 29:.+..+.221++1+212112++21+2+..+++11++
Euphorbia verrucosa 25:+1+.++1.1+1++1...1++++...12+.1+++.
Koeleria pyramidata 33:.221++1+1+.+21+3+22332+11222+2+++++
Carex flacca 27:++....1+++.1.22212+1.+++.1+1+2++2++
Carex caryophyllea 17:1.+.1.+.++.++.....++++...+.+...+.++
Briza media 33:+++++1+12+11++++.++1+11++111++1+2+.
Plantago media 27:1+....+++++.1212+11.1.1++1+1+++++.
Betonica officinalis 18:.1.++.++....++++...++2.+1..+.++..+.
Linum catharticum 25:+.+.+++..++++..++.++++.+++.++.++++
Trifolium montanum 29:.++++1+++.1+1+1.1..++++11++++.++++
Trifolium pratense 15:+.....+++++.+....+.+...++...+.+.++
Dorycnium germanicum 15:.+...++....+..+..+21.++....+++1...
Danthonia decumbens 9:.1...+.+....+...+..1....+.+..++...
Lotus corniculatus 29:2++++.++1++++++1.+1+.++...+++++1+
Plantago lanceolata 29:+1+++++111++++++.++.++.++..+++++++.
Galium verum 27:+2.1211122++11+..+1++1.11.+.2++.+.
Pimpinella saxifraga 28:+++++1.+++++++1.+++.+.1.+++.++.++.+
Genista sagittalis 23:.12221.+++..+21....3+1+11+..+++.2+
Centaurea pannonica 13:...++1+...+..1+....+++.....+1..+.
Succisa pratensis 2:.+.....+.....
Peucedanum oreoselinum 23:133222++....111+1++.12.23...+23.3..
Orchis tridentata 5:+.+.....+.....+.....+.....+
Leontodon hispidus subsp. danubialis 18:11+.++1+.++.....+..++++..+.+..++.
Hypochoeris maculata 9:.+.++++.....+.1..+..+.....
Molinia caerulea 3:.+.....+.....+...+...
Pedicularis acaulis 2:.....+.....+.....
Potentilla alba 5:..+1.....+++....
Orchis morio 7:+...+.....+.....+.+.+....++
Danthonia alpina 26:3.+3++31...2+++.11..21.11+32.+331++



Potentilla erecta	16	.1...1+1+...++.....1.++++1.3+
Inula hirta	8	...+..+.....+.+.....+1.+....+.....
Scabiosa columbaria	7	..+....1.+.....+++.....+...
Carlina acaulis	20	.+++++.+.....+.++.++.+++.++++++
Hippocrepis comosa	26	..++..2+....+++11++1++1++111+21+.++3
Globularia punctata	26	.++++..+.+..+++121..++12+2+11+++1+2
Anthyllis vulneraria subsp. vulneraria	24	.....+++.++++.+11+12+1++1++1+.+.+1
Asperula cynanchica	23	.+.....+1+.+111.11..+11+1+1..11+1++
Centaurea scabiosa subsp. fritschii	20	.....++...+111++1..+11+.2+..+++1
Euphorbia cyparissias	18	+.....+.+..2++.1...+.++++..++++.1+
Stachys recta	15	.....+++...++1.....++.++...+++++..
Scabiosa triandra	20	.....++.+...++.++.++++++1++.+..+1.+
Prunella grandiflora	15	.+.....+..+..+++1+..1.++..++.+++..
Thlaspi praecox	5	.....++.....++....+
Campanula glomerata	7	.....+1+.....+..+...+..+..
Silene nutans	9	.....1...++.....+++..+..+.+
Carex montana	13	.+....2+....1.....22+2.+1...+32
Genista germanica	3	.+.....+.....+.....+...
Cirsium pannonicum	18	.....++...++....11+1+12+2+2+21..
Senecio jacobaea	4	.....+.....+...+.....+.+.
Rhinanthus glacialis	15	.....+1+...+..1..+..+...31.+1.1++.1+
Gymnadenia conopsea	14	.....+.+.....+.++.+.++++++.
Anthericum ramosum	13	...++..+...3.....+3.21...+3322..
Allium carinatum	12	.....+...+..+....++++....++.++.+
Cirsium acaule	9	+.....+..+.....1.....1.+1+.1
Ranunculus nemorosus	9	.+.....+.....+..+...+..++..+.+
Orchis ustulata	9	....+.....+.+++....+++
Teucrium montanum	10	.....+12.+...+++++.+
Aquilegia vulgaris	4	.....+..1..+.....+
Hieracium pilosella	11	.....+.+.....+.+2.+++.+.+
Erica carnea	3	.....++...+.
Thalictrum minus	3	.....++.....+...
Silene vulgaris	3	.....+..+.....+..
Echium vulgare	2	.....+.+.....
Gentiana utriculosa	2	.....+1.....
Chamaecytisus supinus	5	.....+....+...++.+.
Lilium bulbiferum	2	.....+.....+.....
Linum viscosum	4	.....1....+.+.+...
Thalictrum simplex subsp. galioides	8	.....+.....+.+...++++.+.
Gentiana verna subsp. tergestina	**6**	.....+..+..++.+..+
Leontodon incanus	4	.....+....2++
Polygala chamaebuxus	**8**	.....+..+..1+++.23
Dianthus monspessulanus	4	.....+.....++..+.
Antennaria dioica	3	.....++.....+
Knautia illyrica	**7**	.....+.....++++++.
Plantago holosteum	**5**	.....2.1++1.
Tragopogon tommasinii	**5**	.....+.+++.+
Globularia cordifolia	2	.....+..+...
Thesium bavarum	6	.....+...+1+++..
Carex humilis	**7**	.....+32223.1
Potentilla tommasiniana	2	.....+....+
Galium boreale	2	.....+..+..
Plantago argentea subsp. liburnica	**2**	.....1.+...
Polygonatum odoratum	2	.....+.+...
Pseudolysimachion barrelieri subsp. barrelieri	**11**	.....++.....+.1.....+++1+++

Tab. 2: Values of measured and estimated environmental variables for 35 relevés of Slovenian semi-dry grasslands** (Mesobromion erecti **alliance). Legend: E = variables estimated by weighted averages of Ellenberg indicator values.
Tab. 2: Vrednosti izmerjenih in ocenjenih ekoloških parametrov za 35 popisov slovenskih polsuhih travišč (zveza** Mesobromion erecti**). Legenda: E = parametri, ocenjeni s tehtanimi srednjimi vrednostmi Ellenbergovih indeksov.

	Measured variable					Ellenberg values				Species richness/ 25 m²
relevés	$CaCO_3$ (%)	pH (in KCl)	P_2O_5 (mg/100 g)	K_2O (mg/100 g)	Humus (%)	Humidity^E	Light^E	Temperature^E	Nitrogen^E	
1	7.20	7.00	1.60	10.80	12.64	2.91	7.36	5.73	2.43	55
2	7.60	7.17	1.80	19.90	12.50	3.45	6.84	5.71	2.57	69
3	9.60	7.07	1.50	9.60	13.28	3.00	7.60	5.81	2.47	65
4	29.60	7.38	2.40	10.10	11.96	2.40	7.45	5.85	2.84	60
5	12.80	7.15	1.30	8.80	12.02	3.06	6.98	5.88	2.44	62
6	1.24	6.70	1.10	7.20	12.00	2.92	6.85	5.06	2.14	55
7	1.20	6.77	1.10	7.10	11.38	1.78	6.21	4.65	2.42	58
8	21.20	7.25	2.60	10.80	12.46	3.02	7.43	5.37	2.67	53
9	1.00	5.91	1.10	6.20	9.90	3.49	7.96	4.93	2.57	50
10	5.60	6.67	1.90	7.70	11.10	3.24	7.50	5.36	2.59	54
11	1.20	6.85	1.40	8.70	8.80	3.23	7.11	5.74	2.34	50
12	21.60	7.01	0.80	8.00	7.42	3.34	7.19	5.54	2.81	56
13	3.20	6.74	1.40	8.90	6.98	3.31	8.11	5.96	2.15	45
14	29.20	7.18	2.20	7.90	12.12	3.42	7.54	6.12	2.42	42
15	52.00	7.22	1.90	9.30	6.28	2.90	7.30	5.77	2.41	37
16	34.00	7.14	1.20	7.70	3.43	3.32	7.30	5.88	2.51	41
17	4.00	7.00	2.70	9.70	12.34	3.01	7.39	5.42	2.60	51
18	1.20	6.79	1.90	9.50	9.12	3.62	7.36	5.71	2.57	45
19	0.20	5.71	1.10	5.50	7.44	3.64	7.57	5.67	2.78	54
20	0.40	6.30	1.30	6.10	10.26	3.44	7.53	5.71	2.20	50
21	0.04	4.68	1.60	13.80	3.02	3.38	7.73	6.00	2.32	43
22	0.16	5.57	1.50	4.60	6.10	3.51	7.62	5.63	2.69	51
23	0.16	5.48	1.50	7.10	6.40	3.23	7.83	5.73	2.25	37
24	0.16	4.02	0.60	5.90	5.72	3.98	7.17	4.24	2.61	46
25	0.24	4.23	0.90	4.20	3.84	3.27	7.13	5.60	2.35	41
26	0.16	4.96	1.60	3.80	3.77	3.38	6.91	5.98	2.31	50
27	0.20	5.60	0.80	3.00	3.53	3.56	6.99	5.60	2.42	46
28	0.08	6.31	1.40	3.90	4.56	3.43	7.75	5.43	2.91	65
29	0.24	6.19	1.40	7.00	7.16	3.17	7.69	5.58	2.77	65
30	0.20	5.93	1.30	8.50	8.32	3.63	7.71	5.52	2.78	67
31	0.80	6.73	1.30	7.90	5.14	3.13	7.84	5.49	2.79	51
32	29.20	7.32	3.60	5.90	4.71	3.22	7.71	5.62	2.66	45
33	21.20	7.10	4.00	20.40	6.08	3.55	7.26	5.83	2.38	37
34	24.00	7.39	2.90	18.30	5.64	3.54	7.71	5.66	2.68	48
35	3.20	7.17	3.20	5.70	6.16	3.04	8.14	5.61	2.75	51

negatively correlated with soil pH, nitrogen and species richness. Along this axis we could follow the gradient from naturally fertile basic (calcareous) substrates towards acid and leached, infertile soils. The third axis and the fourth axis (as well as the others) are not visible in the two-dimensional ordination, but they are also less important, because they usually describe less than 5% of the total variability.

It is generalised for all types of meadows that fertilisation causes biodiversity loss. Furthermore, dry and semi-dry grasslands are also characterised by low supply of nutrients as the consequence of long lasting removal of aboveground biomass by mowing or grazing without additional fertilization (Gigon, 1968; Grime, 1990; Pils, 1994). But the low level of nutrients must be understood only relatively; due to the results of the present research

Tab. 3: Spearman rank order correlation coefficients (R) between environmental variables. Spearman R is given together with levels of probability # = p < 0.05, $ = p < 0.001.
Tab. 3: Spearmanovi korelacijski koeficienti (R) med ekološkimi parametri, skupaj s stopnjami verjetnosti # = p < 0.05, $ = p < 0.001.

Variable	$CaCO_3$	pH	P_2O_5	K_2O	Humu	$Humi^E$	$Light^E$	$Temp^E$	N^E	Sp.rich.
$CaCO_3$	1									
pH	**0.49#**	1								
P_2O_5	**0.45#**	**0.5$**	1							
K_2O	**0.55$**	0.31	**0.49#**	1						
Humus	**0.37#**	0.11	0.15	**0.45#**	1					
$Humidity^E$	**-0.41#**	-0.22	-0.21	-0.22	**-0.39#**	1				
$Light^E$	-0.17	**0.42#**	0.25	-0.05	-0.19	0.1	1			
$Temperature^E$	0.15	-0.03	0.09	0.27	0.1	-0.24	-0.18	1		
$Nitrogen^E$	0.07	**0.52$**	0.07	-0.05	0	0.11	0.33	-0.26	1	
Species richness	-0.05	0.17	-0.05	0.05	**0.53$**	-0.22	-0.08	-0.07	**0.5#**	1

Tab. 4: Spearman rank order correlation coefficients (R) between environmental variables and CA 1-4. R is given together with levels of probability # = p < 0.05, $ = p < 0.001.
Tab. 4: Spermanovi korelacijski koeficienti (R) med ekološkimi parametri in CA 1-4. R je prikazan skupaj s stopnjami verjetnosti # = p < 0.05, $ = p < 0.001.

Variable	CA1	CA2	CA3	CA4
$CaCO_3$	**0.53#**	-0.4	**-0.41#**	-0.01
pH	-0.06	**-0.83$**	-0.17	0.06
P_2O_5	0.08	-0.3	-0.28	-0.28
K_2O	**0.47#**	-0.26	-0.16	-0.11
Humus	**0.77$**	-0.22	0.18	-0.28
$Humidity^E$	**-0.45#**	0.33	-0.17	-0.09
$Light^E$	-0.39	-0.35	-0.19	-0.07
$Temperature^E$	0.27	0.03	-0.01	-0.18
$Nitrogen^E$	-0.23	**-0.44#**	0.17	-0.17
Species richness	0.27	**-0.41#**	**0.60$**	-0.33

it could be summarised that species richness is positively affected by humus and nitrogen amounts. Deeper and naturally fertile soils enable a very wide spectrum of species, starting from the contingent of *Brometalia* towards to the rich contingent of *Arrhenatheretalia* order as well. It could be interpreted that species richness on naturally fertile soils is high due to the neutrophilous and mesophilous species occurring in these conditions.

It is known that unfertilised semi-dry and dry meadows are colonised by many rare and threatened species, which are adapted to high solar irradiation, heat, drought and cold winter period, to nutrient poor conditions (Ellenberg, 1996) - interpreted also as mineral nutrient stress (Grime, 1976, 1990) – if these selected species are present, those meadows are automatically considered as "species-rich grasslands" due to the presence of "more important" species. Calcareous substrate is also known to increase species richness (Kinzel, 1983), but in our research the correlation between species richness, $CaCO_3$ and pH were not statistically significant. One reason is probably the fact that all the plots have developed on soils on calcareous substrates (dolomite, limestone, marl, flysch). The other reason could be the fact that mainly all sampled plots presented typical Slovenian semi-dry grasslands which were in very good condition, due to the favourable ecological characteristics of the localities and extensive management regime.

POVEZAVA MED EKOLOŠKIMI PARAMETRI, ŠTEVILČNOSTJO RASTLINSKIH VRST IN FLORISTIČNO SESTAVO SLOVENSKIH POLSUHIH TRAVIŠČ ZVEZE *MESOBROMION ERECTI*

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POVZETEK

Polsuha travišča zveze Mesobromion erecti *(Br.-Bl. & Moor 1938) Oberdorfer 1957 sodijo med habitate z visoko biodiverziteto. Floristično diverziteto lahko najpreprosteje označimo kot število vrst na določeni površini (v našem primeru je bila površina 25 m^2). Namen naše raziskave je bil na osnovi 35 raziskovalnih ploskev (sestojev polsuhih travišč, izbranih na območju srednje, vzhodne in jugovzhodne Slovenije) ugotoviti povezavo med floristično sestavo teh travišč, številčnostjo rastlinskih vrst in izbranimi ekološkimi parametri. Vsa izbrana travišča vzdržujejo z ekstenzivno nego – redno košnjo enkrat na leto brez gnojenja. Vegetacijo smo vzorčili po standardni Braun-Blanquetovi metodi. Hkrati s popisi smo na vzorčnih površinah vzeli tudi vzorce tal, ki so jim bile določene naslednje lastnosti: pH, količina organskih snovi, karbonatov ter deleža kalija in fosforja. Razmere na rastiščih smo ocenjevali tudi na podlagi tehtanih srednjih vrednosti Ellenbergovih ekoloških indeksov za svetlobo, vlago, temperaturo in vsebnost dušika. Klasifikacijo fitocenoloških popisov smo opravili z analizo TWINSPAN. Opravljena je bila tudi ordinacija popisov CA (Correspondence Analysis). Na podlagi obeh analiz smo dobili pet dobro ločenih skupin (klastrov) s 5 do 7 popisi. Za interpretacijo floristićnih gradientov, ki so se pokazali po ordinaciji CA, smo koordinate CA posameznih popisov s Spearmanovim korelacijskim koeficientom primerjali s pripadajočimi izmerjenimi in ocenjenimi ekološkimi parametri. Pri tem se je pokazalo, da so številni parametri v statistično značilni korelaciji s koordinatami CA. Prva ordinacijska os je v pozitivni korelaciji z vrednostmi za humus, karbonate, vlažnost in kalij in jo lahko interpretiramo kot gradient od popisov na globokih in vlažnih rjavih tleh, do popisov na plitkih, suhih, karbonatnih tleh. Druga os je v negativni korelaciji z vrednostmi pH in vsebnostmi dušika v tleh; vzdolž te osi lahko spremljamo gradient od naravno hranilnih, bazičnih tal do spranih, kislih in s hranilnimi snovmi revnih, pustih tal. Iz dobljenih rezultatov povzemamo, da je številčnost rastlinskih vrst na traviščih, ki sicer niso umetno dognojevana, v rahli pozitivni odvisnosti z vsebnostmi humusa in dušika v tleh. Iz ordinacije CA, ki temelji na floristični sestavi izbranih eksperimentalnih ploskev, lahko jasno razberemo nekatere ekološke gradiente. Zaključujemo, da so pH, vsebnost humusa, karbonatov in dušika v tleh ter vlažnost tal tisti ekološki dejavniki, ki najmočneje vplivajo na vrstno sestavo polsuhih travišč zveze* Mesobromion erecti *v osrednji, vzhodni in jugovzhodni Sloveniji.*

Ključne besede: *Mesobromion erecti*, polsuha travišča, številčnost rastlinskih vrst, klasifikacija, ordinacija, fitosociologija, Ellenbergovi ekološki indeksi

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PRIMERJAVA POŽGANIH IN NEPOŽGANIH GOZDNIH PLOSKEV NA OSNOVI RASTLINSKIH ŽIVLJENJSKIH OBLIK NA PRIMORSKEM KRASU IN V ISTRI

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IZVLEČEK

Prispevek obravnava vpliv požarov na floristično sestavo vegetacije s poudarkom na življenjskih oblikah višjih rastlin (fanerofiti, hamefiti, hemikriptofiti, geofiti, terofiti). Na območju slovenskega Krasa in Istre je bilo opravljenih nekaj parov popisov v gozdnih sestojih na ploskvah, kjer je pred kratkim gorelo, in na bližnji nepogoreli ploskvi s podobnimi rastiščnimi razmerami. Floristični popisi rastlin so bili opravljeni v treh glavnih aspektih vegetacije, analizirano je le številčno pojavljanje glavnih življenjskih oblik. Ugotovljeno je bilo, da raznolikost rastlinskih vrst vrst po požaru narašča in z razvojem vegetacije v prvotno gozdno obliko upada. Po požaru se v kratkem obdobju v večjem številu naselijo anemohorni terofiti, vendar jih kmalu izrinejo na to okolje bolje prilagojeni hemikriptofiti, hamefiti in fanerofiti. Konkurenčno so najuspešnejše vrste, ki kopičijo zaloge energije v podzemnih trajnih delih. Razmeroma dolga vegetacijska doba in vlažna, mila zimska polovica leta jim omogoča dobro preživetje.

Ključne besede: požari, gozdna vegetacija, življenjska oblika rastlin, submediteran, Slovenija

CONFRONTO TRA PIANE BOSCHIVE ARSE E NON ARSE IN BASE ALLE FORME DI VITA VEGETALI SUL CARSO SLOVENO ED IN ISTRIA

SINTESI

L'articolo tratta l'influenza degli incendi sulla composizione botanica della vegetazione, accentuando i rapporti tra le varie forme di vita delle piante superiori (fanerofite, camefite, emicriptofite, geofite, terofite). Nella regione del carso sloveno e dell'Istria sono stati effettuati diversi inventari su piane boschive recentemente affette da incendi ed in una piana vicina con condizioni di crescita simili, ma non danneggiata dal fuoco. L'inventario delle piante ha tenuto conto di tre aspetti maggioritari della vegetazione; è stata analizzata solo la presenza/assenza delle forme di vita principali. Dai risultati è emerso che in seguito ad un incendio cresce la diversità di specie e forme, per poi diminuire con il successivo sviluppo della vegetazione nella forma boschiva primaria. In un breve lasso di tempo dopo l'incendio si insedia un gran numero di terofite anemocore, che vengono però ben presto sostituite da emicriptofite, camefite e fanerofite, meglio adattate a tale ambiente. Le specie capaci di immagazzinare energia nelle parti sotterranee permanenti sono quelle più concorrenziali, favorite anche da una più lunga durata della vita e da un semestre invernale umido e privo di stress.

Parole chiave: incendi, vegetazione boschiva, forma di vita delle piante, submediterraneo, Slovenia

UVOD

Ogenj je eden izmed ekoloških dejavnikov v kopenskih ekosistemih. Požari so naraven pojav, ki ga povzroča strela, v nekaterih primerih tudi vulkanska dejavnost, ki povzroča vročinski stres in uničuje nadzemne rastlinske biomase v različnem obsegu. Naravno pojavljanje požarov je pogosto v predelih Zemlje z rednim pojavljanjem sušnih obdobij (borealni gozdovi, stepe, savane, območje Sredozemlja in klimatsko podobna območja, subtropska in tropska območja Zemlje) kot tudi v drugih predelih Zemlje, kjer se suša pojavlja občasno. Seveda ni treba posebej poudarjati, da je povzročitelj požarov tudi človek, saj je bila uporaba ognja eden izmed osnovnih dejavnikov v razvoju človeka in kasneje osnova za preproste požigalniške sisteme kmetovanja (Moreno & Oechel, 1994a; Košir, 1997; Johnson & Miyanishi, 2001; Fitter & Ray, 2002). Delovanje ognja je pogubno, saj ogenj uniči večji del ali vso nadzemno rastlinsko biomaso, pogosto tudi organske plasti tal (Moreno & Oechel, 1994a; Košir, 1997; Johnson & Miyanishi, 2001; Urbančič & Dakskobler, 2001). Stalno pojavljanje ognja pa je tudi razlog za nastanek izjemnih, na ogenj prilagojenih oblik rastlin, katerih razmnoževanje je omogočeno z delovanjem visokih temperatur ob požarih, ko zgorijo trdni zaščitni ovoji socvetij oz. plodov in semen in s tem požar oz. ogenj omogoča razširjanje semen in kalitev (Fitter, 2002). V gozdnih ekosistemih s stalnim pojavljanjem požarov so se razvile lesnate rastline s slabo gorljivim, debelim lubjem, veliko sposobnostjo regeneracije iz spečih brstov in sposobnostjo regeneracije iz korenin (Frey & Lösch, 1998; Fitter & Ray, 2002). Učinek ognja na vegetacijo in njen razvoj po požaru je odvisen od vrste požara, tipa in stanja prizadete vegetacije, vremenskih in podnebnih razmer ter lastnosti tal (Allen, 1989; Moreno & Oechel, 1994b, 1995; Bradstock & Auld, 1995; Campbell *et al.*, 1995; Pate, 1995; Košir, 1997; Batič, 2001). Ogenj je ekološki dejavnik, ki ga po Grimovi klasifikaciji opredelimo kot motnjo – disturbanco (Grime, 1979). To je sprememba habitata, ki pomeni uničenje osebka oz. večjega dela biomase. Poleg požarov puščajo podobne posledice še poplave, plazovi, vetrolomi, vulkanski izbruhi in herbivorija v večjem obsegu. Rastline, ki prenašajo motnje, imenujemo ruderalne rastline, označene z R (Grime, 1979).

V Slovenskem primorju je pojavnost požarov v državnem merilu največja (Jakša, 1997; Košir, 1997). Vzrok so podnebne razmere, vrsta in stanje vegetacije, značilnosti tal in dejavnosti ljudi (Čehovin, 1997; Košir, 1997; Prebevšek, 2000; Sardoč, 2002). Preliminarne raziskave spremembe flore po požarih na območju slovenskega Krasa in Istre smo opravili v okviru raziskovalne naloge, ki se je posebej ukvarjala s to problematiko (Jurc *et al.*, 2001). Submediteransko območje je v Sloveniji požarno najbolj ogroženo (Jakša, 1997; Košir, 1997), kar je predvsem posledica razporeditve in količine padavin, lastnosti tal in že prej omenjenih vzrokov. Pri razlagi vpliva požara na vegetacijo je treba upoštevati dejstvo, da je bila ta na tem območju izpostavljena v preteklosti še drugim motnjam, ki so pogosto prešle v stres zaradi prekomerne, dolgotrajne rabe prostora (paša, sekanje gozda, obdelava). Pomembno je tudi dejstvo, da je ta raba v zadnjih 50-70 letih močno zmanjšana, kar pomeni konec močne disturbance. Zaradi vsega naštetega je interpretacija sestave rastlinstva in smeri razvoja združb kot tudi njihovega poimenovanja dokaj zapletena.

MATERIALI IN METODE

Območje raziskav

Pri izbiri raziskovalnih ploskev je bilo prvo izhodišče starost požara in drugo čim bolj podobne rastiščne razmere na karbonatni in na flišni matični podlagi. Raziskava gozdnih požarov je bila opravljena na sedmih lokacijah, v prispevku so prikazani izsledki raziskav z naslednjih petih požarišč:

1. Vremščica (občina Divača, gorelo avgusta leta 1997, talni in vršni, 281 ha, tu in tam zaraščajoči se pašniki in drugotni gozd črnega bora), X = 5 422 750, Y = 5 061 550, n.m.v. 460 m; popisi: 22. 7. 1999, 11. 5. 2000, 12. 10. 2001.

2. Podgovec (občina Sežana, gorelo avgusta leta 1998, talni, 7,53 ha, drugotni gozd črnega bora *(Seslerio autumnalis-Pinetum nigrae),* X = 5 409 156, Y = 5 066 392, n.m.v. 296 m; popisi: 1. 6. 2000, 19. 4. 2001, 12. 10. 2001.

3. Kojnik (občina Koper, gorelo aprila leta 1998, 316 ha, talni in vršni, pašniki ter drugotni gozd črnega bora in termofilnih listavcev), X = 5 418 656,Y = 5 040 536, n.m.v. 780; popisi: 22. 7. 1999, 14. 5. 2001, 2. 7. 2001, 25. 6. 2001, 25. 10. 2001.

4. Strma reber – Diliči (občina Koper, gorelo aprila leta 1999, talni, 14,28 ha, gozd puhastega hrasta in drugih listavcev na flišu), X = 5 404 320, Y = 5 039 113, n.m.v. 277; popisi: 1. 6. 2000. 14. 5. 2001, 2. 7. 2001, 25. 10. 2001.

5. Mlave (občina Sežana, gorelo avgusta leta 2000, vršni, 2,4 ha, drugotni gozda črnega bora in termofilnih listavcev), X = 5 414 500,Y = 5 059 750, n.m.v. 400 m; popisi: 19. 4. 2001, 29. 6. 2001, 12. 10. 2001.

Na vseh mestih smo v pomladnem, poletnem in jesenskem aspektu opravili fitocenološke popise rastlin po kombinirani srednjeevropski metodi ocenitve zastiranja in združnosti vseh pojavljajočih se vrst (Braun-Blanquet, 1964).

Terenske popise smo vnesli v program za urejanje podatkovnih zbirk FloVegSi (Vreš *et al.*, 2001) in analizirali popise glede na življenjske oblike. Fitocenološke pripadnosti in dinamike nismo analizirali. Okvirno

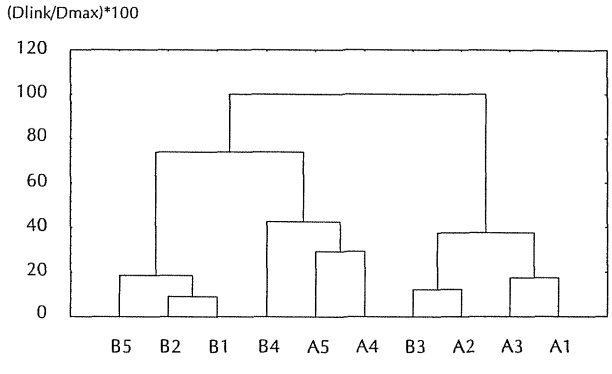
uvrstitev popisnih ploskev v fitocenološke enote smo opravili na osnovi vegetacijskih kart arhiva Biološkega inštituta ZRC SAZU (Acceto *et al.*, 1962-92).

Uvrstitve posameznih vrst v ustrezno skupino življenjskih oblik smo povzeli po Mali flori Slovenije (Martinčič *et al.*, 1999), kjer so podobno kot v drugih florah upoštevane naslednje življenjske oblike: Fa – fanerofiti, lesnate rastline, drevesa in grmi, v preglednicah drevesa Fa1, grmi Fa2; Ha – hamefiti (polgrmi, pritlikavi grmi, zelnate rastline s trajnimi ali vsaj delno trajnimi stebli); He – hemikriptofiti, zelnate trajnice in dvoletnice, ki v neugodnih razmerah odvržejo nadzemna stebla, stanje listov je zelo različno, brsti so tik pod zemeljsko površino ali na njej; Ge – geofiti, zelnate trajnice, ki v neugodnih življenjskih razmerah odvržejo vse nadzemne dele, v tleh ostanejo trajni gomolji, čebule ali korenike; Te – terofiti, enoletnice, ki nimajo trajnega telesa in po vegetacijski dobi ostane od njih le seme. Členitev posameznih skupin življenjskih oblik, kot jo navajajo Dierschke (1994) in Frey & Löschert (1998), v tej obravnavi še ni upoštevana.

REZULTATI

V Tabeli 1 podajamo le okvirne izsledke raziskav spremembe vegetacije zaradi požarov, ker celotna analiza še ni končana. Seznam vseh popisanih vrst je priložen v Tabeli 2. Omejili smo se na primerjalno analizo sprememb števila vrst po požaru in življenjskih oblikah, ki najbolj celovito odsevajo preživetveno strategijo rastlin.

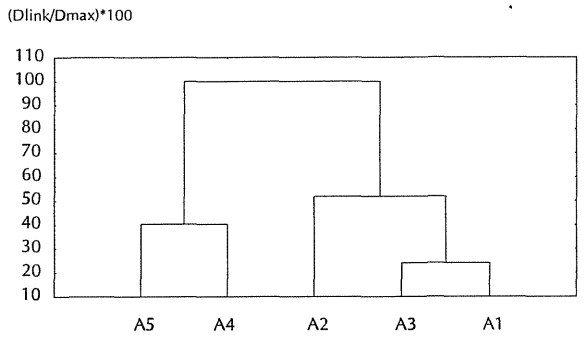
Pojavljanje življenjskih oblik glede na čas požara in predhodno stanje kaže splošno znano dejstvo, da določena, zmerna motnja v sistemu poveča število vrst (Moreno & Oechel, 1994a, 1994b; Košir, 1997; Frey & Löschert, 1998), kar sta v okviru iste raziskave ugotovila tudi Urbančič & Dakskobler (2001) na požarišču na območju Golakov v Trnovskem gozdu. Iz obeh tabel je razvidno, da je v povprečju najmanjše število vrst v gozdu tam, kjer so se posamezne vrste glede na svojo življenjsko obliko in strategijo že ustalile in izrinile manj prilagojene vrste. Iz istega razloga je razumljivo, da ima pašnik več vrst, medtem ko imajo mešane kulture črnega bora z vraslimi listavci zaradi zelo slabih svetlobnih razmer že manjše število vrst, pogosto manj kot gozd puhastega hrasta z jesensko vilovino. Število popisov, ki jih tu navajamo, nam še ne dovoljuje statistične preveritve in je to zgolj logično razmišljanje. Podobne trende smo ugotovili, ko smo preučevali dinamiko spreminjanja števila rastlinskih vrst na Vremščici v odvisnosti od paše (Batič *et al.*, 1999).



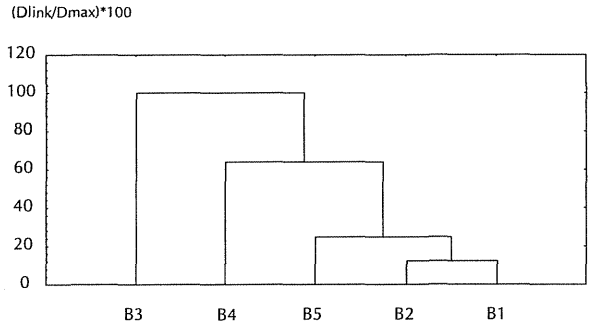
Sl. 1: Evklidska razdalja združenih popisov glede na življenjske oblike (A-pogorele ploskve, B-nepogorele ploskve, 1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).
Fig. 1: Euclidean distance of accumulated relevés according to plant life forms (A-burnt plots, B-unburnt plots, 1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).

Tab. 1: Pregled pojavljanja različnih življenjskih oblik rastlin na ploskvah s časovno določenim požarom (G) in na tistih, za katere mislimo, da v bližnji preteklosti ni bilo požarov (NG).
Tab. 1: Overview of the occurrence of plant life forms at plots with fire (G) and plots in surroundings without fire in the near past (NG).

Objekt	PODGOVEC		VREMŠČICA		KOJNIK		MLAVE		DILIČI	
Čas požara	avg 1998		avg 1997		apr 1998		avg 2000		apr 1999	
Ploskev	G	NG	G	NG	G	NG	G	NG	G	NG
Fanerofiti (Fa)	34	35	41	36	36	43	8	31	23	14
Hamefiti (Ha)	4	3	3	1	10	8	6	0	4	3
Hemikriptofiti (He)	54	14	40	12	54	42	41	11	41	25
Geofiti (Ge)	6	7	3	4	4	1	7	2	5	0
Terofiti (Te)	5	0	3	0	10	1	0	0	1	1
SKUPAJ (Σ)	103	59	90	53	114	95	62	44	74	43
Razlika G/NG	44		47		19		18		31	



Sl. 2: Evklidska razdalja združenih popisov glede na življenjske oblike na pogorelih ploskvah (1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).
Fig. 2: Euclidean distance of accumulated relevés according to plant life forms at burnt plots (1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).



Sl. 3: Evklidska razdalja združenih popisov glede na življenjske oblike na nepogorelih ploskvah (1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).
Fig. 3: Euclidean distance of accumulated relevés according to plant life forms at unburnt plots (1-Podgovec, 2-Vremščica, 3-Kojnik, 4-Diliči, 5-Mlave).

Primerjava podobnosti vseh popisov (Sl. 1) kaže, da je vegetacija na požariščih in nepogorelih ploskvah podobna, saj se skupno grupirajo pogorele in nepogorele ploskve z različnih lokacij in ni jasnejših kopičenj ploskev glede na nadmorsko višino in geološko podlago, kar bi sicer lahko pričakovali. Po drugi strani to niti ne preseneča zaradi relativne geografske bližine in podobne vegetacije kot tudi zaradi relativno šibkih požarov manjše razsežnosti. Primerjava samo pogorelih ploskev (Sl. 2) pa kljub temu kaže na posebnost ploskve na Kojniku, kjer je bil vršni in talni požar in je bila popolnoma uničena drevesna plast, kot tudi ploskve na Diličih zaradi flišne podlage. Pri primerjavi nepogorelih ploskev (Sl. 3) se spet razlikuje Kojnik, kjer je ohranjeni sestoj pretežno črnega bora še mlad in zelo gost, s slabo razvito pritalno vegetacijo. Vraščanje termofilnih listavcev je v začetni fazi. V tem pogledu je podobna tudi ploskev na Mlavah. Druge, Vremščica, Podgovec in Diliči, so vse že sestoji, ki so redkejši, z močno razvito pritalno vegetacijo, v kateri prevladujejo trave, vraščanje listavcev je veliko večje.

ZAKLJUČEK

Učinek požarov je v teh preliminarnih raziskavah mogoče strniti v sledečem: večina požarov, katerih posledice smo preučevali, je bolj ali manj uničila nadzemno biomaso. Uničenje je bilo največje na Kojniku in dosti manjše na ploskvah pod Vremščico, Podgovcih pri Sežani, Diličih in v Mlavah pri Sežani. Le na Kojniku je bila povsem uničena drevesna plast, v drugih primerih so ostala posamezna drevesa listavcev. Tu opažamo razmeroma veliko občutljivost črnega bora na požare, kajti krošnje so zaradi velike vsebnosti terpenov v iglicah, ki imajo ob gorenju veliko energetsko vrednost, skoraj vedno uničene. Po drugi strani črni bor ni sposoben regeneracije iz panja, še manj z nadomestnimi brsti iz korenin (Allen, 1989; Košir, 1997). Nasprotno pa pri večini samoniklih listavcev opažamo, da imajo puhasti hrast (*Quercus pubescens* Willd.), cer (*Quercus cerris* L.), črni gaber (*Ostrya carpinifolia* Scop.), mali jesen (*Fraxinus ornus* L.) pa tudi grmovne vrste (*Cotinus coggygria* Scop., *Frangula rupestris* (Scop.) Schur., *Prunus spinosa* L. itd.) veliko sposobnost regeneracije iz korenin, kar se zgodi že prvo rastno sezono po požaru. Kadar pa požar divja spomladi ali na začetku poletja, se začne regeneracija že isto rastno sezono. Podoben trend opažamo tudi pri večini hemikriptofitov in geofitov, predvsem tistih, ki imajo nadzemne dele aktivne vso rastno sezono. To je verjetno tudi razlog, da niti na eni ploskvi nismo opazili večjega porasta terofitov in dvoletnic, rahla izjema je v tem pogledu ploskev na Kojniku, kjer je bilo prvo sezono po požaru več enoletnic, predvsem po zastrtosti, česar pa v tem prispevku še nismo natančneje analizirali. Ta opažanja kažejo, da so samonikli listavci kraškega območja kot tudi zelnate trajnice v njihovi podrasti na požare dobro prilagojeni in da se po vsej verjetnosti v razmerah, ko ni drugih motenj, vegetacija hitro povrne v prvotno stanje. Analize opravljenih popisov le nakazujejo manjše povečanje nekaterih geofitov na požariščih, kar bi bilo včasih celo zaželeno zaradi ohranjanja nekaterih izredno lepo cvetočih vrst (gorski narcis (*Narcissus poeticus* subsp. *radiiflorus* (Salisb.) Baker), jagodasta hrušica (*Muscari botryoides* (L.) Miller), gorski kosmatinec (*Pulsatilla montana* (Hoppe)Rchb.) ipd.). Poleg enoletnic z lahkimi anemohornimi semeni/plodiči (grinti (*Senecio inaequidens* DC, *Senecio vulgaris* L.), škrbinke (*Sonchus asper* (L.) Hill., *Sonchus oleraceus* L.)) so se na požariščih ponekod dokaj razširile mirmikohorne vrste, predvsem vijolice (*Viola hirta* L., *Viola riviniana* Rchb.), kar bi si lahko razložili z olajšanjem gibanja mravelj, višjimi temperaturami in z odpravo konkurence večjih

rastlin. Pri tem je treba omeniti, da je to le kratko obdobje v zaraščanju, isto ali prvo leto po požaru, in da kasneje te vrste izginejo oz. se pojavljajo v bistveno manjšem številu. Po fazi anemohornih in mirmekohornih vrst, ki sta kratki in neizraziti, je na vseh požariščih opaziti že prvo vegetacijsko sezono po požaru, še bolj pa drugo večje pojavljanje trav, skalne glote *(Brachypodium rupestre* (Host.) Roem. & Schult.) in jesenske vilovine *(Sesleria autumnalis* (Scop.) F.W. Schulzt), na nekaterih ploskvah (Vremščica) pa tudi večje pojavljanje brestovolistne robide *(Rubus ulmifolius* Schott.), navadnega srobota (*Clematis vitalba* L.), črnega trna *(Prunus spinosa* L.), malega jesena *(Fraxinus ornus* L.) in ruja *(Cotinus coggygria* Scop.).

COMPARISON OF BURNT AND UNBURNT FOREST PLOTS BY ANALYSIS OF PLANT LIFE FORMS IN THE FORESTS OF THE SLOVENIAN LITTORAL KARST AND ISTRIA

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SUMMARY

The article deals with post-fire succession of vegetation on chosen sites in the Slovenian Karst and Istria. Introduction briefly presents the influence of fire on vegetation. Regular occurrence of fires leads to special adaptations in plants of their body structure and in mode of reproduction. In European ecological circumstances the occurrence of fire is the greatest in the Mediterranean region, to which the Submediterranean region of Slovenia actually belongs. Six pairs of comparable plots were chosen in the area of the Karst and Istria, one plot with fire in the near past and other without fire in last 50 years. Site history, soil parameters, flora and fauna were investigated on all plots.

Vegetation analysis was carried out by combined assessment of cover and sociability of all plants present at the plot by the Braun-Blanquet method (Braun-Blanquet, 1964). Vegetation records were carried out in spring, summer and late autumn aspect. Only preliminary results are presented, showing vegetation analysis on burnt and unburnt plots by number of plants species and their life forms. Species diversity is higher after fire. In the second year after fire, it is even twice as great as in the Austrian pine plantation or in the broadleaf forest of pubescent oak and hop hornbeam. The greatest regeneration capacity have those species, which are able to resprout from below ground organs (broadleaf trees, hemicryptophytes, cryptophytes and geophytes). The regeneration of those species after fire is so quick that there is very short period when some terophytes become more common due to their light wind distributed seeds or distribution via ants.

Key words: fires, forest vegetation, plant life forms, Submediterranean, Slovenia

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MORPHOMETRICS OF YOUNG KITEFIN SHARKS, *DALATIAS LICHA* (BONNATERRE, 1788), FROM NORTHEASTERN AEGEAN SEA, WITH NOTES ON ITS BIOLOGY

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ABSTRACT

Biological information on five kitefin sharks, Dalatias licha *(Bonnaterre, 1788), three neonates and two post-neonate individuals, captured in October 1999 off the northern coast of Gökçeada (northeastern Aegean Sea) at a depth of 380 m, are given. Morphometric measurements of these specimens are presented. Capture of these neonates and post-neonate individuals near Gökçeada, suggesting that this region may be a nursery area for* D. licha.

Key words: kitefin shark, *Dalatias licha*, morphometrics, stomach contents, reproduction, Aegean Sea

DATI MORFOMETRICI DI GIOVANI ESEMPLARI DI SCIMNORINO *DALATIAS LICHA* (BONNATERRE, 1788) DELL'EGEO NORD-ORIENTALE, CON NOTE SULLA LORO BIOLOGIA

SINTESI

L'articolo fornisce informazioni biologiche su cinque esemplari di scimnorino Dalatias licha *(Bonnaterre, 1788), dei quali tre neonati e due post-neonati, catturati in ottobre 1999 al largo della costa settentrionale di Gökçeada (Egeo nord-orientale) ad una profondità di 380 metri. L'autore presenta i dati morfometrici per tali esemplari. La cattura di questi individui neonati e post-neonati in prossimità di Gökçeada fa presupporre che la regione sia area di nursery* per D. licha.

Parole chiave: scimnorino, *Dalatias licha,* morfometria, contenuti stomacali, riproduzione, mar Egeo.

INTRODUCTION

Kitefin shark, *Dalatias licha* (Bonnaterre, 1788) (Fig. 1), is a common but sporadically distributed deepwater, warm-temperate and tropical shark of the outer continental and insular shelves and slopes from 37 to at least 1800 m depth, but commonest below 200 m (Compagno, 1984). In the Mediterranean Sea, kitefin shark is primarily known from the western part of the area (McEachran & Branstetter, 1984), but several references, indicating its presence in the eastern part, are also available (*e. g.* Akşıray, 1987 from Turkish seas; Meriç, 1995 from the Sea of Marmara; Papaconstantinou, 1988 from Greek seas). No information is available on the biological characteristics of this squaliform shark and the only verified record of the kitefin shark in the seas of Turkey is from the Sea of Marmara based on male specimen caught on the northern continental slope at a depth of 270 m on July 1991 (Meriç, 1995).

In October 1999, a bottom trawler haul at some 380 m off the northern coast of Gökçeada (northeastern Aegean Sea) included five specimens of *D. licha*. The present paper aims to provide additional data on the biology of this squaliform shark.

MATERIAL AND METHODS

Five male specimens of *D. licha* were captured by means of an otter-trawl with a cod-end mesh opening of 22 mm from knot to knot, towed on a muddy-sandy bottom off the northern coast of Gökçeada (40°17'01'' N, 25°52'15'' E; depth 380 m; Fig. 2). Specimens were fixed and preserved in 5 percent seawater-formalin solution. Total lengths (TOT) and forty-seven morphometric measurements of the specimens were measured with a vernier calliper to the nearest 0.05 mm. Morphometric measurements are according to Compagno (1984). Stomachs of the specimens were dissected and their contents identified to the lowest possible taxon, counted and weighed to the nearest 0.5 gram. Counts and weights of the stomach contents were used to calculate the percent by number (PN%), percent by weight (PW%), percent frequency of occurrence (PO%) and Index of Relative Importance (I.R.I.) of each prey organism consumed by the kitefin sharks (Cailliet *et al.*, 1986). I.R.I. of each prey organism was calculated according to the formula (Cailliet *et al.*, 1986) below, and its maximum value would be 20,000:

I.R.I. = (PN% + PW%) x (PO%).

Identification of the species and taxonomic nomenclature follows Compagno (1984). Specimens are kept in the authors' personal collection.

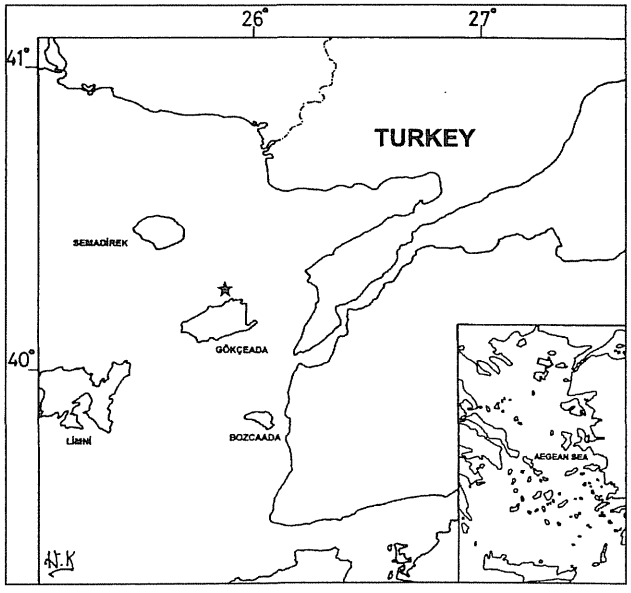

Fig. 2: Sampling location in the northeastern Aegean Sea (drawing by H. Kabasakal).
Sl. 2: Vzorčišče v severovzhodnem Egejskem morju (risba: H. Kabasakal).

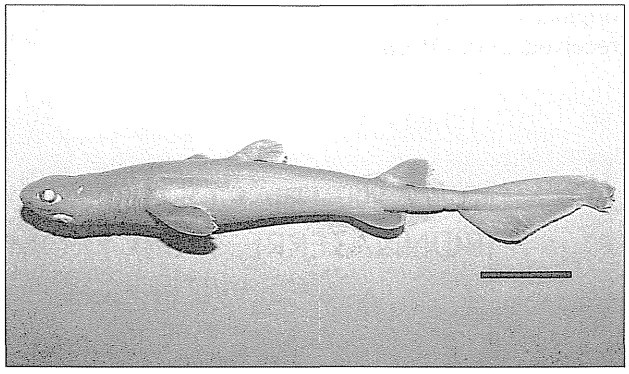

Fig. 1: Kitefin shark, *Dalatias licha* ***(Bonnaterre, 1788), scale bar = 50 mm (photo: H. Kabasakal & E. Kabasakal).***
Sl. 1: Temni morski pes, *Dalatias licha* ***(Bonnaterre, 1788), merilna lestvica = 50 mm (foto: H. Kabasakal & E. Kabasakal).***

RESULTS

Total lengths of the examined kitefin sharks, all males, were 338 mm, 344.2 mm, 372.5 mm, 419.1 mm and 470.2 mm. In the freshly caught specimens, the body was uniformly brownish-grey; the rear margins of dorsal, pectoral and pelvic fins, and the ventral lobe of caudal fin were whitish-edged (Fig. 1); the tips of the claspers were white (Fig. 3). Lateral-line was prominent. The second dorsal fin was slightly larger than the first (Tab. 1, Fig. 1). First dorsal origin somewhat behind free rear tips of pectoral fins, second dorsal origin over about the middle of pelvic bases; both dorsal fins without spines. Gill slits were moderately broad; in the exam-

***Tab. 1: Morphometric measurements of the examined specimens of** D. licha.*
***Tab. 1: Morfometrični podatki pregledanih primerkov** D. licha.*

Specimen Nos	1	2	3	4	5	Mean	TOT % of mean
Sex	♂	♂	♂	♂	♂		
Measurements (in mm)							
TOT	338	344.2	470.2	372.5	419.1	388.8	—
Snout tip to							
1-outer nostrils	3.75	4.7	4.8	4.45	4.8	4.5	1.15
2-eye	9.55	11.35	13.95	12.2	13.55	12.12	3.11
3-spiracle	33.05	34.3	38.55	35.9	38	35.96	9.24
4-mouth	18.6	18	25	22.6	22.35	21.31	5.48
5-1st gill opening	55.4	60.9	69.35	61.05	67.6	62.86	16.16
6-3rd gill opening	64.35	69.85	78.5	71.25	80.15	72.82	18.72
7-5th gill opening	69.45	77.1	86.5	78.65	88.5	80.04	20.58
8-pectoral origin	70.25	78	86.8	78.75	88.55	80.47	20.69
9-pelvic origin	179.55	192.8	228.35	198	226.4	205.02	52.73
10-cloaca	194	200.1	251.45	216.2	249.45	222.24	57.16
11-1st dorsal origin	116.65	124.6	147.4	128.85	145.75	132.65	34.11
12-2nd dorsal origin	197.75	206.75	251.7	219.3	253.6	225.82	58.08
13-dorsal caudal origin	252.65	262.4	326.2	279.4	324.15	288.96	74.32
14-ventral caudal origin	241.85	245.05	316	266.5	315.45	276.97	71.23
Distance between bases							
15-1st and 2nd dorsal fins	68.4	68.3	86.8	76.85	90.25	78.12	20.09
16-2nd and caudal fins	36.7	35.9	50	40.05	44.9	41.51	10.67
17-pectoral and pelvic fins	95.25	97.5	124.9	103.9	120.45	108.4	27.880
Nostrils: distance							
18-between inner corners	11.85	12.55	13.6	12.45	14.35	12.96	3.34
Mouth							
19-width	24.05	25.1	33.75	28.8	32.65	28.87	7.42
Gill opening lengths							
20-1st	4.7	4.9	5.5	5.45	7.25	5.56	1.43
21-3rd	4.35	4.65	4.95	5.45	6.75	5.23	1.34
22-5th	5.35	5.8	7.6	6.1	8.15	6.6	1.69
23-Spiracle: maximum width	5.4	5.5	6.6	6.25	7.1	6.17	1.58
Eye							
24-horizontal diameter	14.6	15.85	15.25	14.8	16.65	15.43	3.96
25-vertical diameter	7.75	7.65	8.3	6.6	8.05	7.67	1.97
26-interorbital width	21.05	22.8	26.5	23.6	26.35	24.06	6.18
1st dorsal fin							
27-overall length	33.85	33.15	42.05	36.3	42.35	37.54	9.65
28- length base	9.65	14.05	18.1	16.95	18.95	15.54	3.99
29-length posterior margin	12.3	13.5	18.2	16.9	17.05	15.59	4.01
30-height	13.2	14	18.65	17.65	15.35	15.77	4.05
2nd dorsal fin							
31-overall length	34.45	35.1	46.85	40.55	48.15	41.02	10.55
32-length base	19.75	19.4	26.8	23.85	26.3	23.22	5.97
33-length posterior margin	16.45	16.25	20.85	19.95	20.35	18.77	4.82
34-height	16.95	16.9	21.1	20.3	20.8	19.21	4.94
Pectoral fin							
35-length base	15.75	16.3	21.65	17.6	19.1	18.08	4.65
36-length anterior margin	42.2	46.3	51.5	45.95	51.65	47.52	12.23
37-length distal margin	17.6	20.85	24	20.95	24.8	21.64	5.56
38-length posterior margin	18.05	24.1	29.85	25.2	26.7	24.78	6.37
Pelvic fin							
39-overall length	38.1	41.55	51.45	44.4	51.15	45.33	11.65
40-length base	21.55	25.4	32.1	27.45	31.1	27.52	7.07
41-length anterior margin	26	31.75	34.7	34.1	33.8	32.07	8.24
42-length clasper	11.85	14.35	21.45	14.8	18.8	16.25	4.17
Caudal fin							
43-length dorsal lobe	83.05	85.7	101.4	98.85	106.1	95.02	24.43
44-length ventral lobe	42.4	42.6	47.95	44.45	46.25	44.73	11.5
45-dorsal tip to notch	16.05	21.1	26.1	23.55	30.2	23.4	6.01
46-depth notch	13.95	16.25	18.25	15.8	17.9	16.43	4.22
Trunk at pectoral origin							
47-height	34.25	33.15	40.05	35.6	43.45	37.3	9.59

***Tab. 2: Composition of the stomach contents of the examined specimens of** D. licha.*
***Tab. 2: Struktura hrane v želodcih pregledanih primerkov** D. licha.*

PREY	PN%	PO%	PW%	I.R.I.
CEPHALOPODA				
Sepietta spp.	18.18	20	21.78	799.36
Loligo vulgaris	9.09	20	4.57	273.32
Cephalopoda (unidentified)	9.09	20	2.17	225.39
Total Cephalopoda	36.36	60	28.54	3894.23
CRUSTACEA				
Parapenaeus longirostris	9.09	20	4.57	273.32
PISCES				
Galeus melastomus	9.09	20	9.15	364.82
Chlorophthalmus agassizii	9.09	20	8.06	343.03
Myctophidae (unidentified)	9.09	20	8.93	360.46
Merluccius merluccius	9.09	20	38.12	944.34
Teleostei (unidentified)	18.18	40	2.61	831.84
Total Pisces	54.54	100	66.88	12143

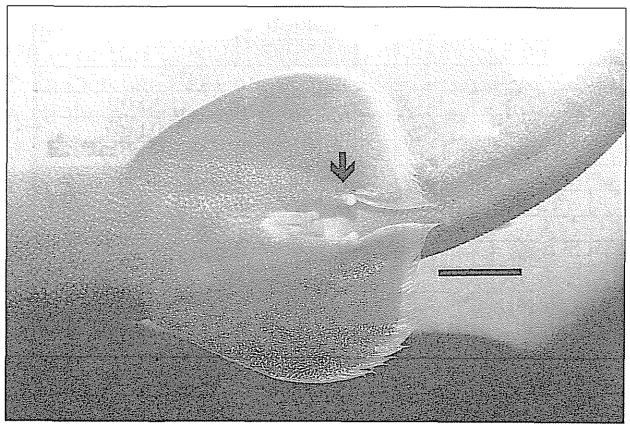

Fig. 3: Claspers of male** D. licha; **arrow indicates the white tips of the claspers, scale bar = 10 mm (photo: H. Kabasakal & E. Kabasakal).
Sl. 3: Spolni organ samca** D. licha; **puščica označuje beli konici spolnega organa, merilo = 10 mm (foto: H. Kabasakal & E. Kabasakal).

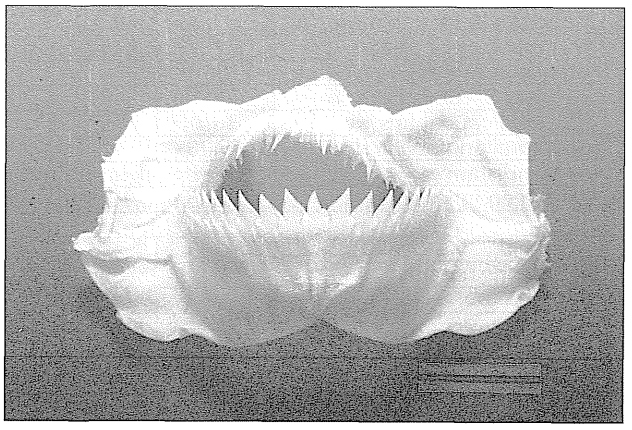

Fig. 4: Dentition in the upper and lower jaws of** D. licha, **scale bar = 10 mm (photo: H. Kabasakal & E. Kabasakal).
Sl. 4: Zobovje v gornji in spodnji čeljusti** D. licha, **merilo = 10 mm (foto: H. Kabasakal & E. Kabasakal).

ined specimens, the 5th gill slits were slightly larger than the remaining gill slits (Tab. 1). Body surface covered by low flat, ridged, unicuspid dermal denticles. Upper teeth were small, slender-cusped and lower teeth large with erect, triangular, blade-like serrated cusps (Fig. 4). Morphometric measurements of the examined specimens are given in Table 1.

Claspers of the examined specimens were uncalcified, soft and clearly shorter than the pelvic fins (Fig. 3). Moreover, sperm were not observed in seminal vesicles of the specimens.

All stomachs of the examined specimens were found to contain food. Prey organisms contained in the stomachs and their numerical data are given in Table 2 and Figure 5.

The three specimens (Nos: 1, 2 and 4; 338 mm, 344.2 mm and 372.5 mm in TOT, respectively) were found to bear healing umbilical scars on ventral surface between their pectoral fins (Fig. 6).

DISCUSSION

Compagno (1984) and McEachran & Branstetter (1984) stated that the common maximum length of *D. licha* is about 159 cm, but it can possibly grow to 182 cm. According to Akşıray (1987), maximum length of this shark in the seas of Turkey is 150 cm. Total length of the largest examined specimen was 470.2 mm and, therefore, specimens of the present study represent only juveniles of the northern Aegean Sea population of *D. licha*. Due to the insufficient morphometric study concerning kitefin sharks captured in the seas of Turkey, it was not possible to compare our data with those of the previous studies. Meriç (1995) reported some undetailed

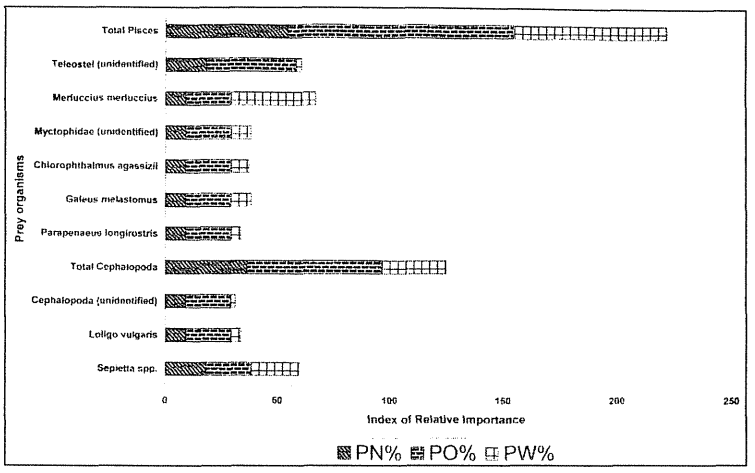

Fig. 5: I.R.I. diagram of the prey organisms and their numerical (PN%), weight (PW%), and frequency of occurrence (PO%) values.
Sl. 5: Diagram I.R.I. (Index relativne pomembnosti plena) in vrednosti, kar zadeva njihovo številčnost (PN%), težo (PW%) in frekvenco pojavljanja (PO%).

morphometric data of a male kitefin shark (345 mm TOT) captured in the Sea of Marmara. According to this author, total length / head length (TOT / HL) ratio of the Marmara specimen was 5.07 and head length / pectoral fin length (anterior edge) (HL / PL) ratio was 1.62 (Meriç, 1995). In the examined specimens, same ratios were as follows: TOT / HL was 4.83 and HL / PL 1.69. The latter ratios (HL / PL) of the present study and of Meriç (1995) are quite similar, but the former ratios (TOT / HL) are clearly different. Standard morphometric measurements of the Marmara specimens of *D. licha* have not been recorded by Meriç (1995), thus it was not possible to make a comparison between the specimens of kitefin shark captured in two different seas.

Macpherson (1980) examined 31 specimens of *Scymnorhinus licha (= D. licha)* and recorded primarily fishes, decapod and natantid crustaceans and cephalopods in the stomachs. The lengths of the examined specimens of *D. licha* by Macpherson (1980) varied between 32 to 100.8 cm and the main prey organisms consumed by those specimens, in the order of importance, were teleosts *Notoscopelus elongatus elongatus*, *Trachyrhynchus trachyrhynchus* and *Phycis blennoides*, blackmouth cat shark *Galeus melastomus*, and decapod *Aristeus antennatus*. In the present study, stomach contents of the examined kitefin sharks were found to contain mainly fishes, followed by cephalopods and decapod *Parapenaeus longirostris* (Tab. 2, Fig. 5). *G. melastomus* was the only chondricthyan consumed by the examined kitefin sharks. In the study area, numerous juveniles of *G. melastomus* were observed in the trawling hauls and it is one of the sharks that co-exist with *D. licha (personal observation by both authors)*. Clarke & Merrett (1972) reported that the high incidence of empty stomachs (90%) of deep sea fishes captured particularly by long-line fishery may be due to the frequent loss of food during their ascent from great depths. However, the examined male kitefin sharks of the present study captured by otter-trawling and their stomachs were completely full. This suggests that, due to the compression in the cod-end the food was not washed out of the stomachs or that the sharks preyed on food in the net. Furthermore, Compagno (1984) stated that for some reason male *D. licha* have full stomachs more commonly than females.

According to Compagno (1984), male *D. licha* reaches maturity at a total length between 77 to 121 cm. Reported size at birth of this species is about 30 cm (Tortonese, 1956; Compagno, 1984; McEachran & Branstetter, 1984). The presence of uncalcified, soft clas-

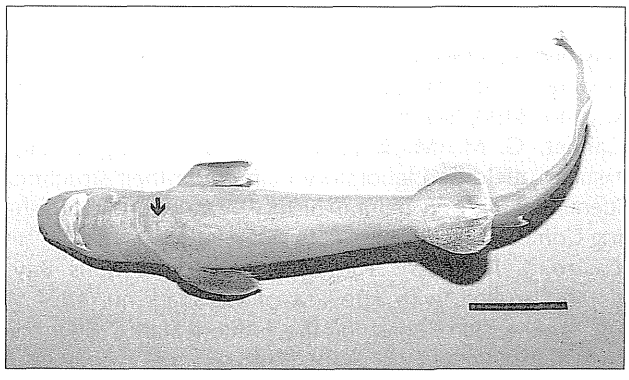

Fig. 6: Healing umbilical scar (arrow) in the male** D. licha, **scale bar = 50 mm (photo: H. Kabasakal & E. Kabasakal).
Sl. 6: Celeča se poporodna brazgotina (puščica) pri samcu** D. licha, **merilo = 50 mm (foto: H. Kabasakal & E. Kabasakal).

pers showed that our specimens were hence juveniles. The lengths of our specimens were also smaller than the reported maturing size of *D. licha*. *D. licha* is an ovoviviparous shark and according to Castro (1993) in the aplacental or ovoviviparous species, neonates are the individuals at or near the birth size, bearing fresh, unhealed or healing umbilical scars. It was observed that three of the examined specimens (Nos: 1, 2 and 4; 338 mm, 344.2 mm and 372.5 mm TOT, respectively) bore umbilical scars (Fig. 6) and were therefore considered neonates. Castro (1993) also stated that the neonatal period terminates with the healing (closure) of the umbilical scar. Thus, the remaining two specimens (Nos: 3 and 5; 470.2 and 419.1 mm TOT, respectively) were post-neonatal individuals because no evidence of umbilical scars was observed in those specimens. Tortonese (1956) stated that the breeding season of *D. licha* in the Mediterranean Sea is in autumn. The capture of the neonates and post-neonatal individuals in October suggests that the breeding season of *D. licha* in the northern Aegean Sea is also in autumn.

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MORFOMETRIČNI IN BIOLOŠKI PODATKI O MLADIH TEMNIH MORSKIH PSIH, *DALATIAS LICHA* (BONNATERRE, 1788), IZ SEVEROVZHODNEGA EGEJSKEGA MORJA

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POVZETEK

Avtorja navajata biološke podatke o petih temnih morskih psih, Dalatias licha *(Bonnaterre, 1788) - treh novoskotenih in dveh malce starejših osebkih - ujetih oktobra 1999 v bližini severne obale Gökçeade (severovzhodno Egejsko morje) v globini 380 m. Predstavljeni so tudi njihovi morfološki podatki. Glede na dejstvo, da so bili ti mladi temni morski psi ujeti v bližini Gökçeade, je verjetno, da je območje razmnoževalno okolje za vrsto* Dalatias licha.

Ključne besede: temni morski pes, *Dalatias licha*, morfometrični podatki, struktura hrane v želodcih, razmnoževanje, Egejsko morje

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NORTHERN RANGE EXTENSION OF THE ORNATE WRASSE, *THALASSOMA PAVO* (LINNAEUS, 1758) (PISCES: LABRIDAE), IN THE EASTERN ADRIATIC

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ABSTRACT

Two adult and one juvenile specimen of Thalassoma pavo *were caught in the areas of Rogoznica (Islet Svilan) and Primošten (Islets Grbavac, Lukovnjak and Maslinovik) in the eastern Adriatic in July and August 2001. This record extends the distribution of this species northward in the Adriatic Sea. Visual censuses were also conducted in shallow waters, where the bulk of juveniles and adults of this species were registered and encountered.*

Key words: *Thalassoma pavo*, range extension, northernmost record, Adriatic Sea

MASSIMA ESTENSIONE A NORD DELLA DONZELLA PAVONINA *THALASSOMA PAVO* (LINNAEUS, 1758) (PISCES: LABRIDAE) IN ADRIATICO ORIENTALE

SINTESI

Due adulti ed un giovane esemplare di Thalassoma pavo *sono stati catturati nelle aree di Rogoznica (isolotto di Svilan) e Primošten (isolotti di Grbavac, Lukovnjak e Maslinovik), in Adriatico orientale, durante i mesi di luglio e agosto del 2001. Tali segnalazioni estendono verso nord la distribuzione di questa specie nel mare Adriatico. La tecnica del Visual census è stata inoltre adoperata per monitorare le acque basse, dove è stata registrata ed incontrata la maggior parte degli esemplari giovani e adulti di questa specie.*

Parole chiave: *Thalassoma pavo*, estensione, segnalazione più a nord, mare Adriatico

INTRODUCTION

Knowledge of mechanisms and processes regulating the size and dynamics of fish populations is important for understanding possible changes in time and, on different spatial scales, populations within their typical distribution area. Even more, such baselines are necessary for studying fish species, which are expanding their distribution limits (Guidetti, 2001). In the last decades, the natural variability of marine communities has been fully recognised and its relation with climate fluctuations hypothesised (Bianchi, 1997). Several authors observed changes in species distribution related to temperature fluctuations, and this especially in the areas close to biogeographical boundaries (Fowler & Laffoley, 1993; Southward & Boalch, 1994); it has been said that climatic shifts induce biogeographical shifts (Southward *et al.*, 1995). Grainger (1992) predicted that the foreseen global warming would probably make southern species extend their range northward. This is apparently what is happening within the Adriatic Sea, where warm-water species have been recently occurring in greater numbers in the northern sectors (Lipej *et al.*, 1996; Bettoso & Dulčić, 1999; Dulčić *et al.*, 1999; Dulčić & Grbec, 2000; Dulčić, 2002). The northward spread of thermophilic species has been considered by several authors as an indirect indication of the Adriatic and Mediterranean water warming and this seems particularly obvious when considering fish assemblages, whose changes in distribution patterns on a large spatial scale may reflect changes in the oceanographic-climatic conditions (Stephens *et al.*, 1988).

The ornate wrasse, *Thalassoma pavo* (Linnaeus, 1758), is a small protogynous labrid fish inhabiting rocky bottoms in the shallow Mediterranean littoral zone, chiefly along the southeastern coasts of the basin (Bini, 1968; Tortonese, 1975; Jardas, 1996). General biology and morphology of *T. pavo* can be found in Bini (1968) and Jardas (1996). It is distributed from Gabon to southern Portugal (Debelius, 1999), and is particularly abundant in the Azores, Madeira and Canaries (Wirtz, 1994). Within the Mediterranean, it is known to occur chiefly in the southern sectors of the basin (Francour *et al.*, 1994). Its distribution pattern leads one to consider this fish to be among the so-called Mediterranean thermophilic southern species. It is rare in the Adriatic, occurring mostly in the southern part (Jardas, 1996).

The present paper discusses northward range extension of the ornate wrasse in the Adriatic Sea and possible mechanisms and causes for such range extension.

MATERIAL AND METHODS

Adult specimens of *T. pavo* were caught by fish trap and the juvenile with a small beach seine. Visual censuses were also conducted in shallow waters, between the surface and 5 m depth, where the bulk of juveniles and adults of this species were registered and encountered according to the method described by Guidetti (2001). Water temperature was measured during each visit. During each survey, all individuals of ornate wrasse were counted and their length (TL) measured to the nearest centimetre. Fish density was expressed as number of individuals/100 m^2 ($log_{10}X+1$ transformed data) for each length category proposed by Guidetti (2002).

The specimens were identified in accordance with Jardas (1996). They were embalmed and deposited in the Ichthyological Collection of the Institute of Oceanography and Fisheries in Split, Croatia. Caught specimens were preserved in 4% buffered formaldehyde immediately after capture, subsequently measured to the nearest 0.1 mm, and weighed to the nearest 0.01 g. Reduction in length caused by preservation depends on initial lengths of the specimens and duration of storage. Meristic characteristics considered were dorsal, anal, pectoral, ventral, caudal fins, and the number of scales in longitudinal line.

RESULTS AND DISCUSSION

Two adult specimens and a single juvenile (Fig.1) of *T. pavo* were caught in the areas of Rogoznica (Islet Svilan) and Primošten (Islets Grbavac, Lukovnjak and Maslinovik) in the eastern Adriatic in July (25.07) and August (10.08) 2001, between 3 and 5 m depth at rocky bottom with varying slopes (gentle to steep), comparatively rich in crevices and colonized by erected macroalgae.

Morphometric and meristic data are given in Table 1. Standard counts and measurements fit previous descriptions of the species, such as in Jardas (1996). Surface temperature (average value) during investigation was 24.2°C in July and 25.1°C in August. The total length examined during the study period (by visual census) ranged from 4 to 23 cm TL. Number of individuals/100 m^2 ($log_{10}X+1$ transformed data) was from 0.6 to 0.8 (size-class 4-8 cm), from 1.3 to 1.6 (size class 9-13 cm), from 0.7 to 0.9 (size class 14-18 cm) and from 0.8 to 0.9 (size class 19-23 cm).

This record of ornate wrasse in the Rogoznica (Islet Svilan) and Primošten area (Islets Grbavac, Lukovnjak and Maslinovik) in the eastern Adriatic represents, to our best knowledge, the northernmost occurrence of this species in the Adriatic Sea (eventhough there are some indices that one male was recorded by visual census near island Prvić – cape Šilo – northern Adriatic, Kružić, *pers. comm.*). A successive range extension to the north from 1991 until now is presented in Fig. 2. The numbers of thermophilic species caught during the past few years have increased in the Eastern Adriatic (Dulčić & Grbec, 2000). Several species, scarce until now, are more

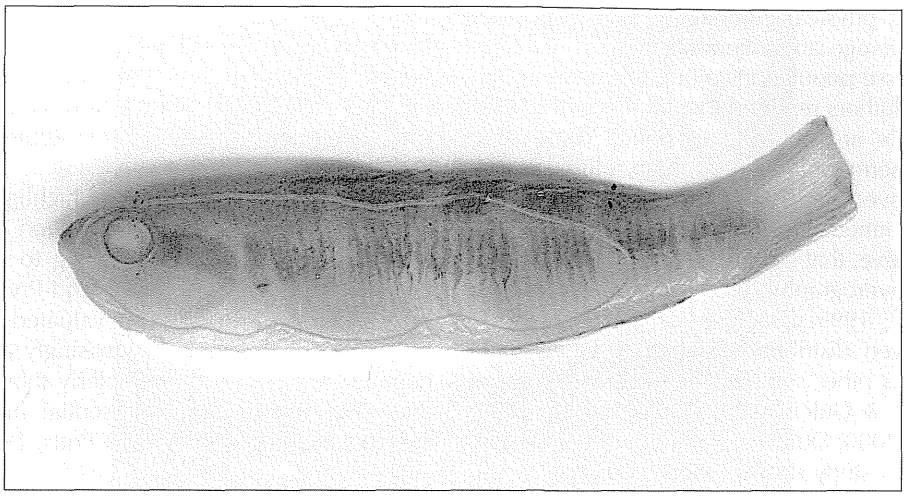

Fig. 1: Juvenile specimen of the ornate wrasse (5.3 cm TL) caught at Rogoznica (Islet Svilan).
Sl. 1: Mladostni osebek pavjega kneza (5,3 cm TL), ujet v bližini Rogoznice (otoček Svilan).

abundant, while others are new to the area. Climate change can influence marine communities by a combination of: *a) direct effect on the organisms (e.g.* direct influence of temperature, causing changes in survival, reproductive success, dispersal pattern and behaviour); b) *effects mediated by biotic interactions;* and c) *indirectly through ocean currents* (changes in climate may alter the emphasis of water flow and the pattern of water circulation) (Southward *et al.*, 1995). According to some authors (Stephens *et al.*, 1988; Francour *et al.*, 1994; Dulčić & Grbec, 2000), temperature is the most important large-scale variable, which could affect fish populations, while Pallaoro (1988) stated the Adriatic ingressions increasing salinity and temperature caused more rare species to appear and increase abundance in the central Adriatic region. This northernmost record and increased occurrence of this species in the southern and central Adriatic could indicate a possible wider expansion to the northern parts, which has already been recorded for the other areas in the Mediterranean. The increased occurrence of *T. pavo* in the Ligurian Sea in recent years supports the hypothesis of the establishment of true populations of warm-water species in the Ligurian Sea. It is in further expansion in the Ligurian Sea and presently reproduces there, thus getting independent from the larval supply from the Tyrrhenian Sea (Vacchi *et al.*, 1999, 2001). A comparative expansion of the ornate wrasse northward in the western Mediterranean was reported, and the relationship between this event and climate changes hypothesized (Astraldi *et al.*, 1994). Several other authors (Bianchi & Morri, 1993, 1994; Francour *et al.*, 1994) also pointed out that the recent spreading of the ornate wrasse in the northernmost sectors of the western Mediterranean could be a response to ongoing seawater warming. Densities of ornate wrasse appeared to be related to the surface water temperature, with higher densities during warmer months (Guidetti, 2002). Guidetti *et al.* (2002) pointed that climatic conditions *(e.g.* water temperature along the latitudinal gradient) and substrate features *(e.g.*

Tab. 1. Biometric (cm) and meristic data of** Thalassoma pavo **caught by fish trap and beach seine in the areas of Rogoznica and Primošten.
Tab. 1: Biometrični (cm) in meristični podatki o pavjem knezu** Thalassoma pavo, **ujetem z vršo in mrežo v območju Rogoznice in Primoštena.

Measurements (cm)	♂	♀	Juv.
Total length	19.31	12.93	5.30
Standard length	15.42	10.60	4.44
Head length	4.83	3.18	1.31
Orbital diameter	0.72	0.55	0.36
Interorbital width	1.05	0.68	0.43
Preorbital length	1.55	1.07	0.37
Postorbital length	2.51	1.59	0.71
Predorsal distance	4.65	3.35	1.29
Preventral distance	4.90	3.85	1.44
Preanal distance	8.70	5.65	2.54
Prepectoral distance	4.51	3.16	1.37
Dorsal fin length	8.63	6.23	2.42
Anal fin length	4.51	3.84	1.11
Ventral fin length	1.32	1.19	0.54
Pectoral fin length	3.27	2.03	0.92
Caudal fin length	4.69	2.58	1.12
Maximum height	4.82	3.07	1.05
Caudal peduncul height	2.18	1.49	0.59
Dorsal ray	VIII / 13	VIII / 13	VIII / 12
Anal ray	III / 11	III / 12	III / 11
Pectoral ray	15	15	15
Ventral ray	I / 5	I / 5	I / 5
Lateral line scale	29	30	28

macroalgal cover, physical complexity, slope) are thus likely to affect average abundances and size structures of the ornate wrasse populations along the western Italian coast. Same authors reported that factors acting on a geographical scale are likely to influence distribution patterns of the thermophile fish *T. pavo*, although significant effects have been also observed at the smallest spatial scale examined. Finally, it could be suggested, from this perspective, that the present seawater warming and changes in hydrographic properties of the Adriatic Sea (Dulčić *et al.*, 1999; Dulčić & Grbec, 2000) is altering the observed distribution pattern of the ornate wrasse, as well as other southern fish species (Lipej *et al.*, 1996; Bettoso & Dulčić, 1999; Dulčić *et al.*, 1999; Dulčić & Grbec, 2000; Dulčić & Pallaoro, 2001; Dulčić, 2002). The present study showed that the ornate wrasse juveniles settle and inhabit the same habitat occupied by adults, which has been confirmed by Guidetti (2001) for the Thyrennian Sea. This pattern is consistent with the data reported for other labrid fishes in- and outside the Mediterranean basin (Garcia-Rubies & Macpherson, 1995; Green, 1996).

In conclusion, these results highlight aspects of the population dynamics and distribution of *T. pavo* in the Adriatic Sea (especially according to mentioned possibility of its occurrence near island Prvić) and the status of this species needs to be evaluated on a continuous basis, as it is becoming increasingly apparent that uncommon species, and particularly those on the edge of their distribution, can be essential indicators of environmental changes (Swabby & Potts, 1990).

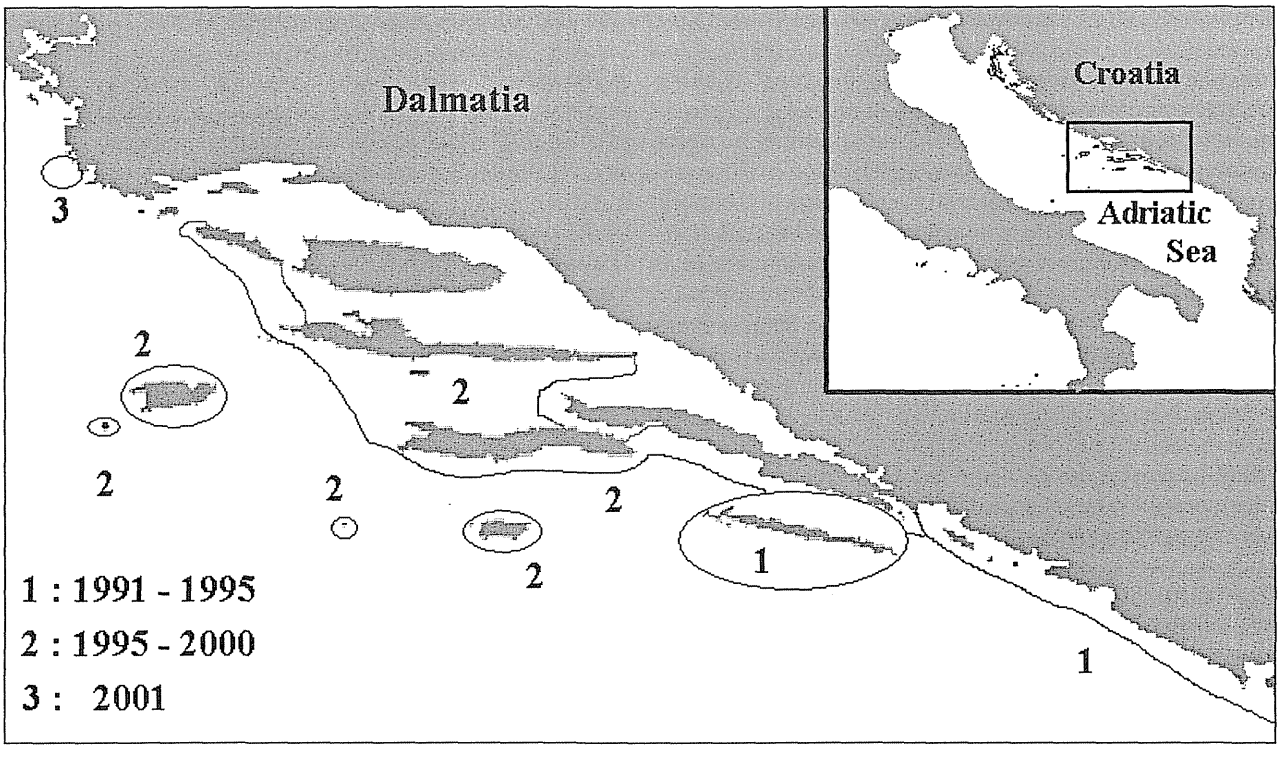

Fig. 2: The succesive spreading of the ornate wrasse to the northern parts (1: 1991-1995, 2: 1996-2000 and 3: the record in 2001 – Rogoznica and Primošten area; eastern Adriatic).
Sl. 2: Sukcesivno širjenje pavjega kneza proti severu (1991-1995, 1996-2000 in zapisi v letu 2001 iz območja Rogoznice in Primoštena).

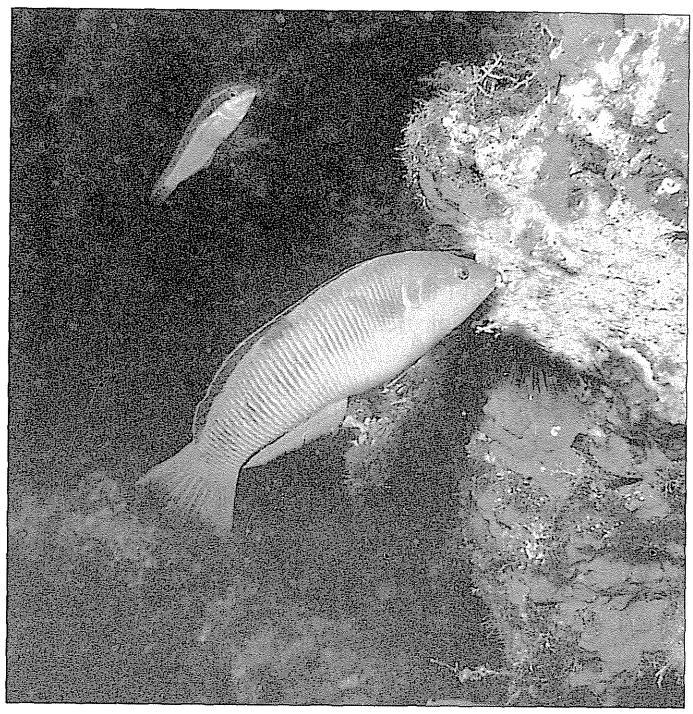

Fig. 3: Ornate wrasse *(Thalassoma pavo)* ***(Photo: M. Richter).***
Sl. 3: Pavji knez *(Thalassoma pavo)* ***(Foto: M. Richter).***

ŠIRJENJE AREALA PAVJEGA KNEZA *THALASSOMA PAVO* (LINNAEUS, 1758) (PISCES: LABRIDAE) V VZHODNEM JADRANU PROTI SEVERU

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POVZETEK

V juliju in avgustu 2001 so bili v Rogoznici (otoček Svilan) in v okolici Primoštena (otočki Grbavac, Lukovnjak in Maslinovik) v vzhodnem Jadranu ujeti dva odrasla in en mladostni osebek pavjega kneza Thalassoma pavo. *S temi najdbami se je meja razširjenosti v Jadranskem morju pomaknila proti severu. V plitkih vodah so potapljači opravili tudi vizualna štetja in tam zabeležili največje število mladostnih in odraslih osebkov te vrste.*

Ključne besede: *Thalassoma pavo*, meja razširjenosti, najsevernejši zapis vrste, Jadransko morje

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STOMACH CONTENTS OF THE LONGNOSE SPURDOG, *SQUALUS BLAINVILLEI* (RISSO, 1826) FROM THE NORTH-EASTERN AEGEAN SEA

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ABSTRACT

Examination of the stomach contents of the longnose spurdogs, Squalus blainvillei *(Risso, 1826), captured in the NE Aegean Sea suggests that they mainly consumed, in order of importance, crustaceans and teleost fishes (I.R.I. = 7098.59 and 2734.8, respectively).* Liocarcinus *spp. and* Parapenaeus longirostris *were the most frequent prey items of the examined specimens of longnose spurdogs (I.R.I. = 2072.74 and 1143.2, respectively).*

Key words: Squalidae, longnose spurdog, *Squalus blainvillei*, stomach contents, Aegean Sea

CONTENUTI STOMACALI DELLO SPINAROLO BRUNO, *SQUALUS BLAINVILLEI* (RISSO, 1826) DELL'EGEO NORD-ORIENTALE

SINTESI

L'esame dei contenuti stomacali di spinarolo bruno, Squalus blainvillei *(Risso, 1826), catturato nell'Egeo nord-orientale, suggerisce che la sua alimentazione si basi, in ordine di importanza, su crostacei e teleostei (I.R.I. = 7098.59 e 2734.8, rispettivamente).* Liocarcinus *spp.* e Parapenaeus longirostris *sono risultati le prede più frequenti degli esemplari esaminati di spinarolo bruno (I.R.I. = 2072.74 e 1143.2, rispettivamente).*

Parole chiave: Squalidae, spinarolo bruno, *Squalus blainvillei*, contenuti stomacali, mar Egeo

INTRODUCTION

The longnose spurdog, *Squalus blainvillei* (Risso, 1826) (Fig. 1) is a widespread member of the family Squalidae and it generally occurs at depths between 16 and 440 m (Compagno, 1984). The occurrence of this shark in the Mediterranean Sea as well as along the Turkish coast is well documented by several researchers (*e.g.*, Akşıray, 1987; Kabasakal, 2002a, *in press;* McEachran & Branstetter, 1984; Slastenenko, 1955-1956; and Tortonese, 1956).

Elasmobranchs are among the top predators in the marine environment and have an important role in the marine ecosystem in relation to the populations of both fish and invertebrates at lower trophic levels (Ellis *et al.*, 1996). Furthermore, there is always a competition between the fishermen and the marine predators feeding on commercially valuable species, and the interactions among these predators and the populations of commercially important marine species should therefore be carefully examined (Kabasakal, 2002b, in *press).* There have been several studies describing the stomach contents of the squaliform sharks of a specific area in the Mediterranean Sea, for example, Jardas (1972a, 1972b) in the Adriatic Sea, Kabasakal & Ünsal (1999) and Karaçam *et al.* (1996) in Turkish seas, and Macpherson (1980) in the western Mediterranean.

The aim of the present study is to provide some preliminary data on the stomach contents of *S. blainvillei,* captured in the NE Aegean Sea.

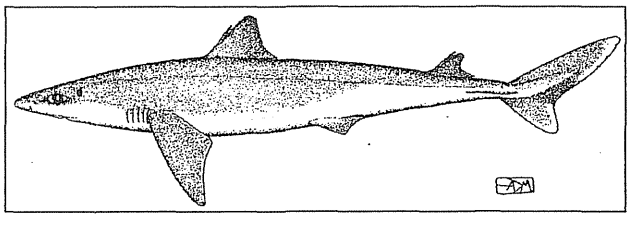

Fig. 1: Longnose spurdog, *Squalus blainvillei* ***(Risso, 1826). (Drawing: A. De Maddalena)***
Sl. 1: Rjavi trnež, *Squalus blainvillei* ***(Risso, 1826). (Risba: A. De Maddalena)***

MATERIAL AND METHODS

In November 2000, specimens of *S. blainvillei* were collected by means of a commercial fishing trawler with a cod-end mesh opening of 22 mm from knot to knot, in the NE Aegean Sea (Station 1: 40°28′ N - 26°00′ E, depth = 80 m, n = 20; Station 2: 40°33′ N - 25°59′ E, depth = 70 m, n = 25; Fig. 2). All haulings were carried out during the day time. Total length (TOT; according to Compagno, 1984) of the sharks was measured to the nearest mm with a mesuring tape. Total lengths of the examined sharks ranged between 350 to 420 mm. Di-

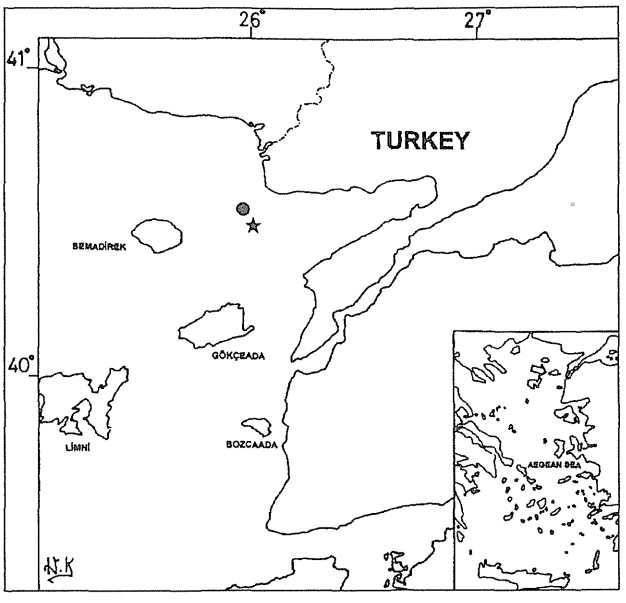

Fig. 2: Sampling stations in the north-eastern Aegean Sea (★, indicates St. 1 and ●, indicates St. 2); (⇨) on the small map indicates the area investigated.
Sl. 2: Vzorčišča v severovzhodnem Egejskem morju (★ ponazarja 1. vzorčišče, ● 2. vzorčišče); (⇨) na malem zemljevidu označuje raziskovano območje.

gestive tracts of the specimens were removed and immediately fixed in 5 percent formalin in sea water. The fixed stomach contents were finally preserved in 70% ethanol. Prey items found in the stomachs were identified to the possible lowest taxon. Preys were dried on the paper towel at room temperature for one hour, weighed to the nearest 0.05 g on precision balance and then counted. Percent numerical (PN%), weight (PW%) and frequency of occurrence (PO%) values of prey items were calculated, and these values were used to calculate the Index of Relative Importance "I.R.I." of each prey item, according to the following formulae (Cailliet *et al.*, 1986):

I.R.I. = (PN% + PW%) x PO%

According to Cailliet *et al.* (1986), the maximum value of I.R.I. would be 20000. The number of fish with empty stomachs was expressed as a percentage of the total number examined (the Index of Vacuity, *IV*; Ellis *et al.* 1996).

RESULTS AND DISCUSSION

The aim of the stomach content analysis is to provide information on the contribution of different prey to the diet, indicating the position of a fish within the general trophic web. Thirty-three (73.3%) of the 45 examined stomachs of *S. blainvillei* were found to contain food *(IV* = 26.6%). Dietary composition of full stomachs is summarised in Table 1 and graphically expressed in Fig. 3.

Tab. 1: Composition of the stomach contents of the examined specimens of** Squalus blainvillei, **and numerical (PN%), weight (PW%), and frequency of occurrence (PO%) values of prey items.
Tab. 1: Struktura hrane v želodcih pregledanih primerkov rjavih trnežev** Squalus blainvillei **in vrednosti, kar zadeva numeričnost (PN%), težo (PW%) in frekvenco pojavljanja (PO%) enot plena.

PREY	PN%	PW%	PO%	I.R.I.
ELASMOBRANCHII				
Scyliorhinus canicula	0.16	1.61	3.03	5.37
TELEOSTEI				
Sardina pilchardus	0.33	4.55	3.03	14.8
Engraulis encrasicolus	0.66	0.79	9.09	13.26
Mullus surmuletus	0.33	3.94	6.06	25.92
Cepola rubescens	0.33	2.75	6.06	18.69
Gobiidae spp.	0.33	1.25	3.03	4.81
Unidentified teleost remains	18.84	14.89	90.9	3067.09
Total Teleostei	20.82	9.25	90.9	2734.8
CRUSTACEA				
Parapenaeus longirostris	5.12	8.34	84.84	1143.2
Liocarcinus spp.	6.61	14.76	96.96	2072.74
Goneplax rhomboides	1.32	1.41	18.18	49.79
Unidentified crustacean remains	44.95	14.96	100	5992.27
Total Crustacea	58.01	12.96	100	7098.59
CEPHALOPODA				
Sepia elegans	1.98	16.39	24.24	445.57
Unidentified cephalopod remains remains	0.66	6.57	6.06	43.83
Total Cephalopoda	2.64	7.54	30.3	308.79
POLYCHAETA				
Euphrosine foliosa	0.49	0.72	6.06	7.38
Unidentified tissues	17.85	5.68	100	2353.58
Total weight of food items (g)	304.33			
Total number of food items	605			

The data in this study suggest that *S. blainvillei* mainly consumed, in order of importance, crustaceans and teleost fishes (I.R.I. = 7098.59 and 2734.8, respectively, Tab. 1). Crustaceans were found in all of the examined stomachs and the epibenthic decapods consisted the major part of the identified crustaceans. *Liocarcinus* spp. and *Parapenaeus longirostris* were the most frequent prey items of the examined specimens of longnose spurdog (I.R.I. = 2072.74 and 1143.2, respectively, Tab. 1 and Fig. 3). Regarding its I.R.I value, *Sepia elegans* occupies the third rank (I.R.I. = 445.57) after *Liocarcinus* spp. and *Parapenaeus longirostris*. In comparison with the most frequent prey organisms, I.R.I. values of the polychaete, *Euphrosine foliosa*, and the lesser spotted catshark, *Scyliorhinus canicula*, were remarkably lower (I.R.I. = 7.38 and 5.37, respectively, Tab. 1 and Fig. 3), and in the light of this result, both animals can be considered as accidental preys of *S. blainvillei*.

Jardas (1972a) examined 43 Adriatic specimens of *S. blainvillei* and recorded three species of benthic and epibenthic teleost fishes, five species of crustaceans and four species of cephalopods in the stomachs. Jardas (1972a) also reported that *S. blainvillei* has a preference for Cephalopoda and Crustacea in its diet. However, in the present study, by contrast, cephalopods occupy the third rank (I.R.I. = 308.79, Tab. 1) after crustaceans and teleost fishes.

Predation on the eggs and juveniles of the scyliorhinids by squaliform sharks has been well documented in some species (Barrull & Mate, 2001, in *Oxynotus centrina*; and Macpherson, 1980, in *Dalatias licha*). The continental shelf and slope of the northern Aegean Sea is recognized as a breeding and nursery ground for several elasmobranchs, including scyliorhinids by D'Onghia *et al.* (1995) and Kabasakal (2002a, *in press*). Because of their high fat and protein content as well as the easy accesibilty, cat shark eggs and neonates can be an important nutritional source for bottom-dwelling sharks. It would be worth finding out how this predation by squaliform sharks could affect the catshark population over this nursery ground.

Although preliminary, the analysis of the stomach contents of *S. blainvillei* indicates that the longnose spurdog is a generalist predator feeding mainly on crustaceans and teleost fishes, as well as cephalopods and polychaetes.

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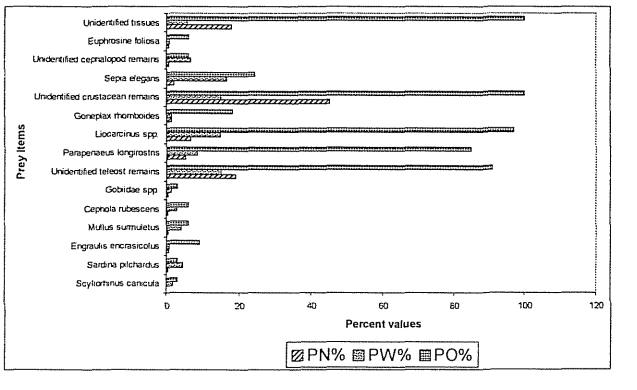

Fig. 3: I.R.I. diagram of the prey items and their numerical (PN%), weight (PW%), and frequency of occurrence (PO%) values.
Sl. 3: Diagram I.R.I. (Index of Relevant Importance) enot plena in vrednosti, kar zadeva številčnost (PN%), težo (PW%) in frekvenco pojavljanja (PO%) plena.

STRUKTURA HRANE V ŽELODCIH RJAVIH TRNEŽEV, SQUALUS BLAINVILLEI (RISSO, 1826), IZ SEVEROVZHODNEGA EGEJSKEGA MORJA

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POVZETEK

Pregled strukture hrane v želodcih rjavih trnežev, Squalus blainvillei *(Risso, 1826), ujetih v SV Egejskem morju, kaže, da so se hranili, glede na pomen hrane, predvsem z raki in pravimi kostnicami (I.R.I. = 7098.59 in 2734.8).* Liocarcinus *spp. in* Parapenaeus longirostris *sta bili najpogostejši enoti hrane v pregledanih primerkih rjavih trnežev (I.R.I. = 2072.74 in 1143.2).*

Ključne besede: Squalidae, rjavi trnež, *Squalus blainvillei*, struktura hrane v želodcih, Egejsko morje

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LEBETUS GUILLETI (TELEOSTEI: GOBIIDAE) IN THE NORTHERN ADRIATIC SEA: FIRST RECORD AND DETAILS ON THE SPECIES' MORPHOLOGY

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ABSTRACT

The occurrence of Lebetus guilleti *(Le Danois, 1913) is described for the first time from the northern Adriatic Sea, Croatian coastal waters. Eight females (SL 12.1-17.4 mm) and five males (SL 10.6-12.5 mm) were collected in the Kvarner region, south of Rijeka on sandy substrates at depths between 6 and 13 m in 1999 and 2001. A second small population was documented photographically along the western coast of Istria, near Rovinj in May 2002. The collected specimens were assigned to* L. guilleti *(Le Danois, 1913) by the following features: small body size, specific body coloration, complete loss of the head lateral line canals, presence of suborbital row a, limited number of head sensory papillae with two interorbital rows, elongate dorsal fin rays and meristic values of D2 I/7-8, A I/4-5, P 14-15, LL 24-26 and VC 25-26. This recent finding enables a more detailed description of the morphology of this little known species as given below. Morphometrics, meristic values, lateral line system, coloration and skeletal features as well as ecology are described and compared with related gobiid genera.*

Key words: Gobiidae, *Lebetus guilleti*, Mediterranean, northern Adriatic Sea

LEBETUS GUILLETI (TELEOSTEI: GOBIIDAE) IN ADRIATICO SETTENTRIONALE: PRIMA SEGNALAZIONE E DETTAGLI MORFOLOGICI

SINTESI

Gli autori segnalano per la prima volta la presenza di Lebetus guilleti *(Le Danois, 1913) nell'Adriatico settentrionale, in acque croate. Otto femmine (SL 12.1-17.4 mm) e 5 maschi (SL 10.6-12.5 mm) sono stati trovati nella regione quarnerina a sud di Fiume, su substrati sabbiosi tra i 6 e i 13 metri di profondità. Un'altra popolazione è stata scoperta più a nord, vicino a Rovigno. Gli esemplari sono stati attribuiti alla specie* Lebetus guilleti *(Le Danois, 1913) in base alle seguenti caratteristiche: piccole dimensioni corporee, colorazione corporea specifica, assenza completa di canali lineari laterali sul capo, presenza della fila suborbitale* a, *numero limitato di papille sensorie sul capo con due file interorbitali, raggi della pinna dorsale allungati e valori meristici di D2 I/7-8, A I/4-5, P 14-15, LL 24-26 e VC 25-26. Tale recente scoperta permette di dare una descrizione più dettagliata della morfologia di questa poco nota specie. I valori morfometrici e meristici, il sistema lineare laterale, la colorazione e le caratteristiche scheletriche nonché l'ecologia vengono descritte e comparate con i correlati generi di gobidi.*

Parole chiave: Gobiidae, *Lebetus guilleti*, Mediterraneo, Adriatico settentrionale

INTRODUCTION

The taxonomy within the genus *Lebetus* Winther, 1877 has been somewhat confusing since the two species *Gobius orca* and *G. scorpioides* were described by Collett (1874) and assigned to a new genus by Winther (1877). These two species, which were mainly distinguished by coloration, turned out to be females and males of a single species exhibiting specific sexual dichromatism (Miller, 1961, 1963). The valid name for this species was supposed to be *L. orca* initially, but had to be changed to *L. scorpioides* later (Miller, 1971). At that time it turned out that two different species actually exist, both found within the material of *L. scorpioides*, indistinguishable by coloration patterns but by different postlarval development and meristic characters of subadult specimens. The new species, described from specimens of *scorpioides*-material, was designated as *L. guilleti*, raising the subspecies *L. scorpioides guilleti* by Le Danois (1913) to species level (Miller, 1971). Both *L. scorpioides* (Collett, 1874) and *L. guilleti* (Le Danois, 1913) had previously been known only from the northeastern Atlantic boreal region, especially around the British Isles, the western Channel and south-western Scandinavia, and some early records made near the Strait of Gibraltar were considered doubtful (Miller, 1963). The occurrence of the genus *Lebetus* in the Mediterranean Sea was reported first by Zander (1982), who found one specimen at Banyuls-sur-Mer/France in June 1979, which was assigned to *L. guilleti*. Now, two small populations of this species have been discovered in the northern Adriatic Sea along Croatian coast, one in the Kvarner region south of Rijeka and another along the western coast of Istria, close to Rovinj (Fig. 1), greatly extending the known distribution area within the Mediterranean Sea. These recently collected specimens exhibit distinct adult features and are therefore used to describe the morphology of this species. Morphometrics, meristic values, lateral line system, osteology and coloration as well as a short note on the ecology of *L. guilleti* are provided.

MATERIAL AND METHODS

Material: 1 specimen; northern Adriatic Sea, Croatia, Kvarner region, Klenovica, south of Rijeka, close to Selce: 1 ♀, 17.4 + 4.3 mm (PMR VP1022), 07.09.1999, leg. Kovačić. 12 specimens; northern Adriatic Sea, Croatia, Kvarner region, Selce, south of Rijeka: 1 ♀, 12.8 + 4.0 mm (CH 38:1) and 1 ♂, 12.6 + d mm (CH 38:2), 12.04.2001, leg. Herler; 4 ♀♀, 12.1 + 3.9 to 14.5 + 4.3 mm (CH 38:3, 5, 7, 8), 2 ♂♂, 11.3 + 4.0 mm (CH 38:6) and 11.9 + 3.9 mm (CH 38:4), 2 ♀♀, 12.6 + 4.3 mm and 13.1 + 4.1 mm, 2 ♂♂, 10.6 + 4.0 mm and 10.9 + 3.6 mm (NMW 94589-94592), 30.04.2001, leg. Herler.

Compared material: 1 specimen; western Mediterranean Sea, France, Banyuls-sur-Mer: 1 ♂, 12.9 + 4.6 mm (ZMH 7969), June 1979, leg. Zander.

The fish were collected with hand nets and photographed after anaesthetics (quinaldine diluted with ethanol 1:15) were dispersed from a squeeze bottle. The size of fish is given in SL+Cl (d=damaged). For osteological descriptions, two specimens, 1 ♀ 12.8 + 4.0 mm (CH 38:1) and 1 ♂ 12.6 + d mm (CH 38:2), were cleared and stained with alcian-blue and alizarin-red. Near Rovinj, six specimens were observed during a single dive in May 2002; two were documented photographically, but no collection took place.

Morphometrics: Ab, anal fin base; Ad and Aw, body depth and width at anal fin origin; Cl, caudal fin length; CHd, cheek depth; CP and CPd, caudal peduncle length and depth; D1b and D2b, first and second dorsal fin bases; E, eye diameter; H and Hw, head length and width; I, interorbital width; Pl, pectoral fin length; PO, postorbital length; SL, standard length; SN, snout length; SN/A and SN/AN, snout to anal fin origin and anus; SN/D1 and SN/D2, snout to origin of first and second dorsal fins; SN/V, snout to pelvic disc origin; UJ, upper jaw length; V/AN, pelvic disc origin to anus; Vd, body depth at pelvic disc origin; Vl, pelvic disc length.

Meristics: A, anal fin; C, caudal fin; D1, D2, first and second dorsal fins; LL, scales in lateral series; P, pectoral fin; TR, scales in transverse series; V, pelvic disc; VC, number of vertebrae.

Collections: CH, collection Herler; NMW, Museum of Natural History Vienna; PMR, Museum of Natural History, Rijeka.

RESULTS

Morphology

Identification: The specimens were assigned to *Lebetus guilleti* (Le Danois, 1913) by meristic features D2 I/7-8, A I/4-5 and 25-26 vertebrae. The small body size, typical habitat choice and conspicuous brown and white body coloration also enables easy discrimination in the field. Slight differences in the coloration between *L. guilleti* and the congeneric *L. scorpioides* are given in Table 2.

General morphology: Body proportions are given in Table 1. Body small, laterally compressed with dorsoventral symmetrical shape. Head relatively small and slightly depressed, with large eyes longer than snout. Eyes positioned dorsolateral resulting in narrow interorbital space. The mouth is oblique with short upper lip extending back only to below anterior edge of orbit. Anterior nostril a short tube without process from rim, posterior nostril with only slightly ascending rim. Branchiostegal membrane attached to side of isthmus at ventral origin of P, and membrane not fused across isthmus.

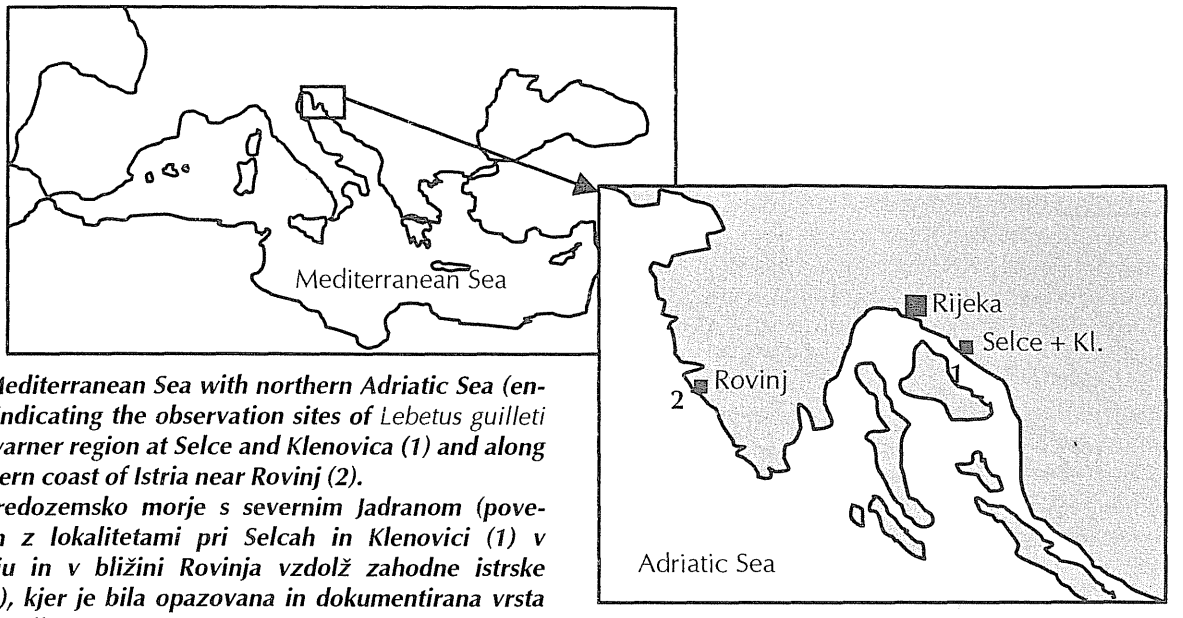

Fig. 1: Mediterranean Sea with northern Adriatic Sea (enlarged) indicating the observation sites of *Lebetus guilleti* ***in the Kvarner region at Selce and Klenovica (1) and along the western coast of Istria near Rovinj (2).***
Sl. 1: Sredozemsko morje s severnim Jadranom (povečano) in z lokalitetami pri Selcah in Klenovici (1) v Kvarnerju in v bližini Rovinja vzdolž zahodne istrske obale (2), kjer je bila opazovana in dokumentirana vrsta *Lebetus guilleti.*

Tab. 1: Morphometric values in both sexes of the northern Adriatic *Lebetus guilleti.* ***n = number of specimens; s = standard deviation.***
Tab. 1: Morfometrične vrednosti pri obeh spolih severnojadranske vrste *Lebetus guilleti.* ***n = število primerkov; s = standardni odklon.***

		Lebetus guilleti (Le Danois, 1913)					
Sex		♂♂			♀♀		
SL		10.6 - 12.5 mm			12.1 – 17.4 mm		
n		5			8		
		range	mean	s	range	mean	s
%SL,	H	29.8-30.6	30.1	0.3	29.9-32.5	30.9	0.8
	Hw	17.2-18.9	17.9	0.6	16.9-21.8	18.3	1.5
	SN/D1	36.7-38.7	37.8	0.8	36.9-39.4	37.9	1.0
	SN/D2	58.0-61.3	59.8	1.3	58.4-61.5	59.9	1.1
	SN/AN	52.3-58.3	55.9	2.0	56.3-60.6	58.5	1.5
	SN/A	58.9-62.8	61.4	1.4	61.9-66.7	64.7	1.5
	SN/V	30.5-34.5	32.6	1.7	30.4-34.4	32.3	1.4
	CP	22.7-24.5	23.6	0.7	21.8-26.8	23.4	1.5
	D1b	10.7-12.3	11.5	0.6	11.2-15.5	12.3	1.4
	D2b	21.4-25.5	23.6	1.4	21.5-25.3	23.0	1.3
	Ab	14.0-17.9	15.7	1.7	13.3-16.6	15.0	1.0
	Cl	32.9-37.7	34.9	1.9	24.7-34.0	31.3	2.8
	Pl	26.5-28.9	27.6	1.1	21.8-27.6	25.2	1.6
	Vl	28.2-33.1	31.1	1.7	27.6-32.4	30.4	1.5
	Vd	17.9-20.1	18.9	0.9	16.6-21.3	18.6	1.6
	Ad	15.3-19.6	17.3	1.5	14.6-18.0	16.6	1.1
	Aw	10.3-13.0	11.2	1.0	9.2-13.2	11.0	1.2
	CPd	10.4-12.2	11.1	0.7	9.6-11.5	10.4	0.6
	V/AN	23.9-26.2	25.0	0.7	26.3-30.0	28.5	1.3
	E	9.1-10.8	9.9	0.6	8.6-10.8	9.9	0.8
% CP,	CPd	42.9-51.9	46.9	3.3	39.6-50.2	44.5	3.0
% H,	SN	22.6-27.1	24.8	1.4	22.0-27.8	25.1	2.0
	E	30.0-35.3	32.9	2.0	28.8-35.2	32.1	2.1
	PO	44.8-48.3	47.1	1.3	44.7-48.8	46.5	1.4
	CHd	11.7-15.1	13.2	1.4	11.8-14.9	13.5	1.1
	Hw	56.8-61.8	59.4	1.9	54.4-73.1	59.3	5.6
	UJ	27.4-33.7	30.6	2.3	28.6-35.8	31.7	2.4
% E,	**I**	18.2-23.2	20.2	1.7	11.3-18.5	14.8	2.8
% V/AN,	**Vl**	118.0-130.6	124.3	4.3	98.0-115.4	106.8	5.2

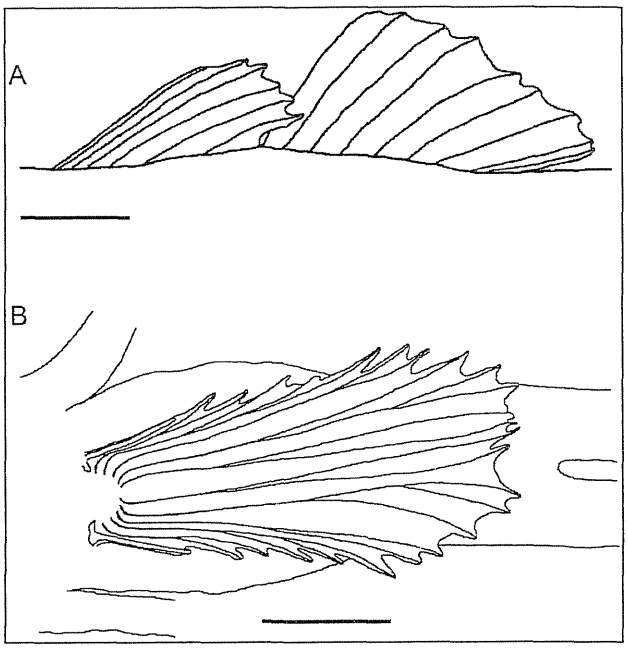

Fig. 2: Fin shapes in** Lebetus guilleti. **(A) D1 and D2, ♂, 10.6 + 4.0 mm; (B) ventral fin, ♂ 10.9 + 3.6 mm. Scale bar = 1 mm.
Sl. 2: Oblike plavuti vrste** Lebetus guilleti. **(A) D1 in D2, ♂, 10,6 + 4,0 mm; (B) trebušna plavut, ♂ 10,9 + 3,6 mm. Merilo = 1 mm.

Teeth in both jaws in three rows, enlarged in first of these, erect and caniniform. Sexual dimorphism, apart from sexual dichromatism described below, can be seen in some body proportions (Tab. 1). Females show a longer abdomen through higher values in SN/AN, SN/A and V/AN (all in % SL). The caudal and pectoral fins (Cl and Pl in % SL) are somewhat shorter in ♀♀. In interorbital width (I in % E) the ♀♀ are exceeded by the ♂♂.

Fins (Fig. 2): D1 VI; D2 I/7-8 (7:8, 8:5); A I/4-5 (4:4, 5:9); C (branched rays) 8-10 (8:3, 9:8, 10:1, d:1); P 14-15 (14:9, 15:4); V I/5+I/5. Rays of median fins D1, D2 and A elongated especially in males. In P, all rays are within membrane. V truncate, V4 and V5 usually of same length or latter slightly shorter, with no anterior membrane developed. C slightly rounded to truncate. Segmented fin rays branched only in C and V.

Scales: LL 24-26 (24:3, 25:4, 26:4, d:1). TR 7-8 (7:12, 8:1). Squamation occurs only on the trunk, while nape, predorsal area back to end of D1 base, opercle, breast and belly are naked. The scales on the trunk are ctenoid and are easily lost in preserved specimens.

Vertebrae: VC 25-26, including urostyle (10 precaudal + 15 caudal vertebrae and 11 + 15 respectively).

Lateral line system (Fig. 3): No head canals present and a low number of superficial neuromasts. Rows of papillae were lettered according to Miller (1963) as given for *L. scorpioides* (formerly *L. orca)* but adapted to a more recent nomenclature (Miller, 1986) in some rows. Number of papillae are given as the most frequent values in parentheses.

1.) Preorbital: Snout with only few papillae. Row *rs* (2-3) close to each other and to posterior nostril, row *s* (1) more distant on anterior edge of snout. Rows *c* with c^2 (1) near posterior nostril and c^1 (5) downward from anterior nostril.

2.) Suborbital: Row *a* (5) with longitudinal extension termed row a^1 (2) from posterior edge of orbit. 3 to 4 papillae irregularly distributed on upper cheek and therefore difficult to assign to row *b* or *c*. Row *d* (1-2) on posterior edge of lower jaw.

Tab. 2: Inter- and intraspecific comparison of morphological differences within the gobiid genus** Lebetus **from different geographical regions.
Tab. 2: Inter- in intraspecifična primerjava morfoloških razlik znotraj rodu** Lebetus **iz različnih geografskih regij.

Species	***L. scorpioides***	***L. guilleti***	***L. guilleti***
Location	north-eastern Atlantic	north-eastern Atlantic	northern Adriatic
Reference	Miller (1963, 1971)	Miller (1971)	this study
	n = 76	n = 6	n = 13
Features:			
D2 soft rays	9-10	7-9	7-8
A soft rays	7-8	5-6	4-5
Vertebrae	27-29	25-26	25-26
D1 shape (♂♂)	enlarged, rounded	?	smaller, triangular
D1 coloration (♂♂)	dusky yellow, white edged	?	grey, 2 yellow bands
D2 coloration (♂♂)	4 broad red bands	?	6 yellow bands
Postlarvae (5-6 mm):			
Ventral fin length	< 10% SL	> 10% SL	?
Melanophores (A base)	absent	present	?

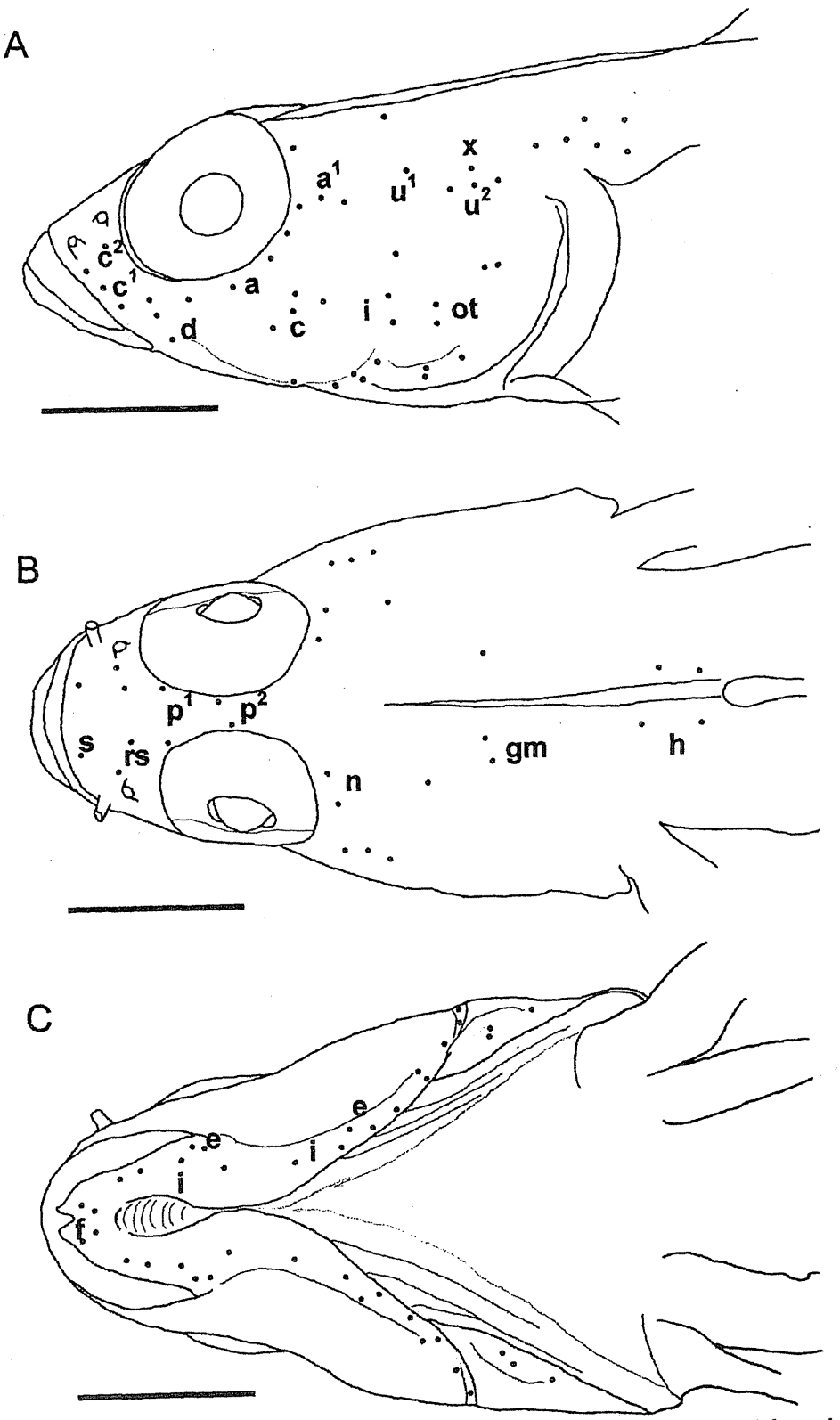

Fig. 3: Lateral line system of the northern Adriatic** Lebetus guilleti; ♂, **10.9 + 3.6 mm. (A) lateral view, (B) dorsal view, (C) ventral view of head. Scale bar = 1 mm.
Sl. 3: Sistem pobočnice pri severnojadranskih primerkih vrste** Lebetus guilleti; ♂, **10,9 + 3,6 mm. (A) glava s strani, (B) s hrbtne strani, (C) s trebušne strani. Merilo = 1 mm.

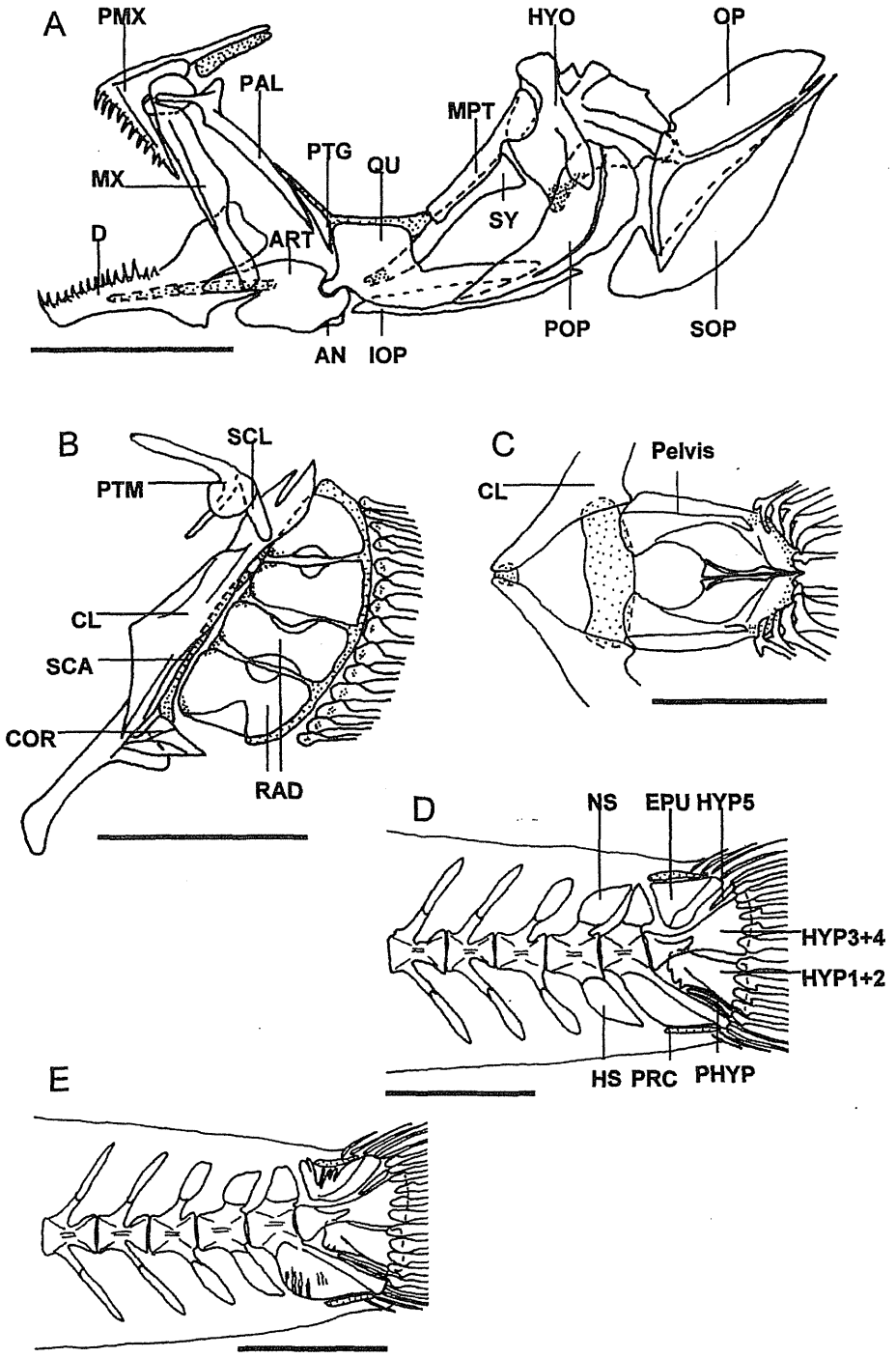

***Fig. 4: Skeleton of the northern Adriatic** Lebetus guilleti; ♀, 12.8 + 4.0 mm (A - D) and ♂, 12.6 + d mm (E). (A) Jaws, suspensorium and opercle series; (B) pectoral girdle; (C) pelvic girdle; (D, E) last vertebrae and caudal skeleton; all in lateral view. Bones white, cartilage stippled. Scale bar = 1 mm. AN, retroarticular; ART, anguloarticular; CL, cleithrum; COR, coracoid; D, dentary; EPU, epural plate; HS, hemal spine; HYO, hyomandibular; HYP, hypural; IOP, interopercle; MPT, metapterygoid; MX, maxilla; NS, neural spine; OP, opercle; PAL, palatine; PHYP, parhypural; PMX, premaxilla; POP, preopercle; PRC, procurrent cartilage; PTG, ectopterygoid; PTM, posttemporal; QU, quadrate; RAD, radials; SCA, scapula; SCL, supracleithrum; SOP, subopercle; SY, symplectic.*
***Sl. 4: Skelet severnojadranskih primerkov vrste** Lebetus guilleti; ♀, 12,8 + 4,0 mm (A - D) in ♂, 12,6 + d mm (E). (A) Čeljusti, oporni in operkularni nizi; (B) oplečje; (C) okolčje; (D, E) zadnja vretenca in obrepni skelet; vse s pogledom s strani. Kosti bele, hrustanec pikčast. Merilo = 1 mm.*

3.) Preoperculo-mandibular: Papillae of posterior part of external row *e* (1-2) along preopercle, distant from each other, those of the anterior part (2) close to each other at posterior edge of lower jaw. Internal row *i* in three parts with superior section (2) along upper preopercle, posterior section (6) along lower preopercle, and anterior (4) section along lower jaw. Mental row *f* (2) in clear distance from rows *e* and *i*.

4.) Oculoscapular: Row u^1 (1) in the middle of postorbital region. Row *x* (1) more posterior, with row u^2 (3) below this. Row *xy* (1) above upper end of opercle. Row *z* (1) superior to superior section of row *i*. Axillary series represented by rows as^1 (2), as^2 (1), as^3 (1), la^1 (1) and la^2 (1) clearly separated.

5.) Opercular: Transverse row *ot* divided into upper (2-3) and lower (1-2) section. Rows *os* (1-2) and *oi* (1-2) present.

6.) Anterior dorsal: Row *n* (3) with section of two papillae along posterior edge of orbit and one in distance from orbit. Rows *g* and *m* (1-3) together and difficult to assign, in most cases forming a triangle on each side. Row *h* (2-3) usually before origin of D1.

7.) Interorbital: Row p^1 (1) in anterior and p^2 (1) in middle part of interorbital space on each side close to orbit.

8.) Trunk: Dorsal series with ld^1 (1) near D1 origin, ld^2 (1-2) below posterior part of D1 and ld^3 (2-3) on upper edge of caudal peduncle. Median rows *ltm* in 7 to 10 short (1-3) transverse rows. Ventral series with lv^1 (2-3) between origins of P and V, lv^2 (2-3) in middle of abdomen and lv^3 (2-3) above anus.

9.) Caudal: Three papillae in short transverse row at C origin. One median longitudinal row (2-4) originating from middle papillae of former row.

Osteology (Fig. 4): Both stained specimens well ossified. Apart from vertebrae and pterygiophores no major differences in the skeleton of the stained male and female were observed. Hyoid (not shown in Fig. 4): 5 branchiostegal rays, first thin and attached to slender anterior process of axe-shaped anterior ceratohyal. Rays 2, 3 and 4 on broad part of the latter. Fifth blade-like ray attached to posterior ceratohyal.

1.) Jaws, suspensorium and opercular series (Fig. 4a): Teeth present on premaxilla and dentary. Both elements with three rows of caniniform teeth at symphysis, decreasing to one row posterolaterally. Teeth in outer row enlarged. Premaxilla with long ascending and articular process, posterior part short, joining only the anterior half of maxilla. Postmaxillary process absent. Maxilla broad only in first two thirds, last third splint-like, overlapping dentary plate and dorsally anguloarticular when mouth opened. Palatine slender with thin process inserting in anterodorsal end of maxilla. Ectopterygoid as small bone between palatine and quadrate. Anguloarticular inserts in dentary with pointed anterior process, while the ventral ramus is plate-like. Posterodorsal, anguloarticular articulates with quadrate. Retroarticular small, ventromedial at posterior end of anguloarticular. Metapterygoid small, laterally overlapping hyomandibular and anterodorsal half of symplectic. Latter attaching to quadrate medially. Posterior ramus of quadrate overlapped by anterior ramus of preopercle, latter dorsally fixed between plate and inferior process of hyomandibular.

2.) Pectoral girdle (Fig. 4b): Post-temporal with two processes and thin plate, which overlaps the articulation with supracleithrum. Cleithrum relatively straight in lateral view, strongly bifid at dorsal end and with ascending plate from middle part. In lower third bony plates, which join the pelvic intercleithral cartilage on both sides. Ventral intercleithral cartilage between ventrally joining left and right cleithrum. Coracoid inserting close to ventral bony plate of cleithrum. Scapula unossified, slender with dorsal foramen. Four large proximal radials surrounded by cartilaginous areas. The tiny distal radials are cartilaginous.

3.) Pelvic girdle (Fig. 4c): Pelvis joining large pelvic intercleithral cartilage anteriorly. Pelvic fin rays insert on cartilaginous posterior rim of pelvis. Medially rod-like bones project forward from posterior inner rims of pelvis.

4.) Axial skeleton and median fins: 25-26 vertebrae, including urostyle. Variation was found in number of precaudal vertebrae with 10 and 11, respectively. The number of caudal vertebrae was 15 in both stained specimens, with hemal arches closed. In lateral view, first five vertebral centra becoming progressively longer and less wide backwards. First two centra shorter than wide. The absence of one precaudal vertebra in the female specimen (CH 38:1) seems to impinge on the arrangement of the pterygiophores of D1 and D2. D1 shows the formula 3-2301 instead of 3-2211 as exhibited by the male (CH 38:2). Two free interneural spaces between pterygiophores of D1 and D2 and therefore three pterygiophores of D2 before the first caudal vertebra in the male, but only two in the female. In both specimens, the number of proximal pterygiophores in D2 resembles the count of all fin rays, that in A only the count of soft rays. Pleural ribs are found on third to last precaudal vertebrae, therefore 8 and 9 in number, attached to parapophyses of vertebrae. Epipleural ribs on second precaudal vertebra to fourth caudal vertebra (13 and 14). First epipleural rib attached to second vertebra, remaining precaudal attached to pleural ribs. First two caudal epipleural ribs attached to vertebrae, last two loose contact.

5.) Caudal skeleton (Figs. 4d, 4e): Neural spines and hemal spines of last three vertebrae enlarged, especially last hemal spine expanded, larger in male. Dorsal and ventral procurrent cartilage slender, joining large epural

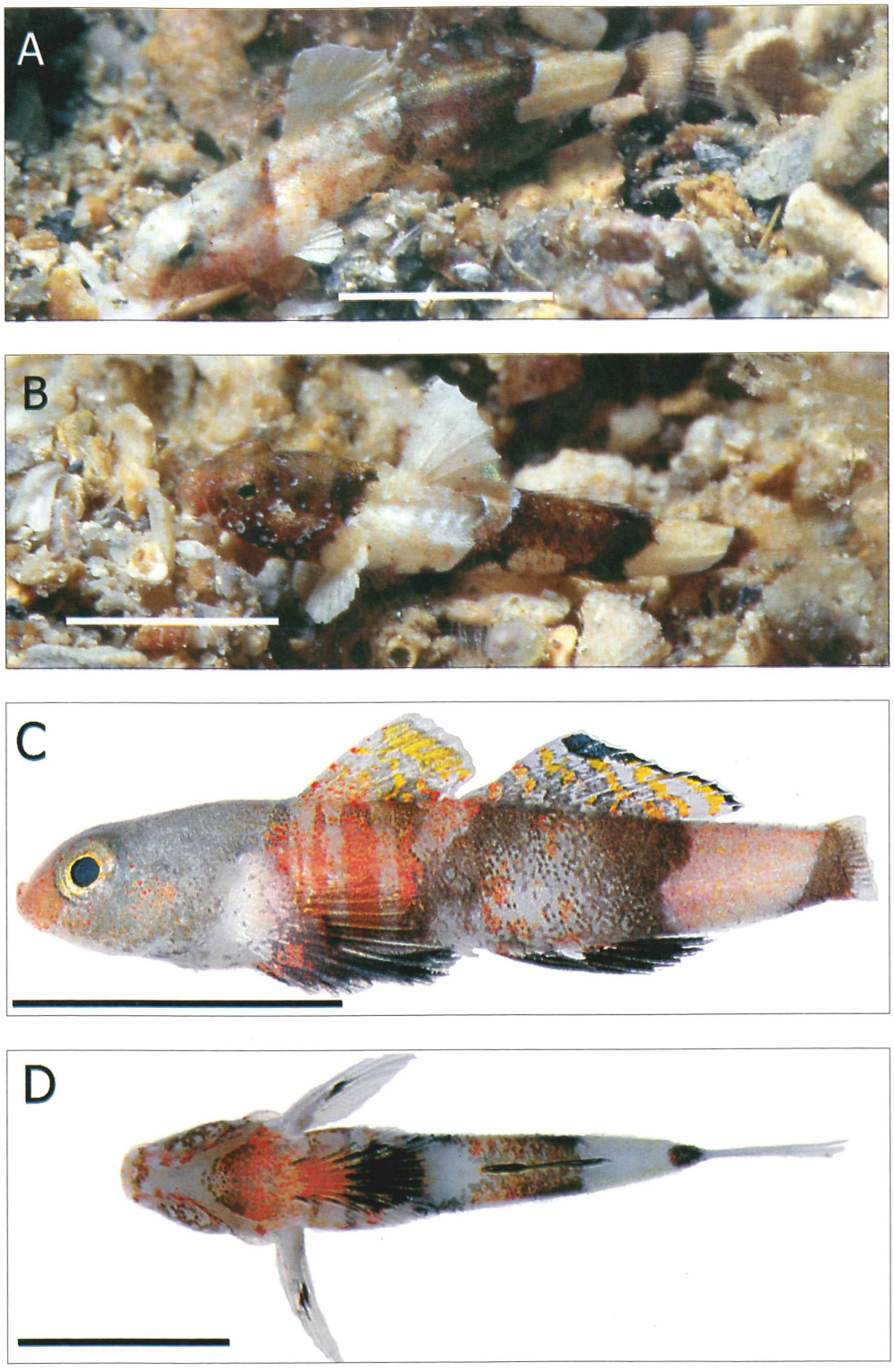

Fig. 5: Coloration of the northern Adriatic** Lebetus guilleti. **Male (A) and female (B) in the natural habitat. More colourful variations are shown after narcotisation and/or recent preservation in formaldehide: (C) ♂, 12.6 + d mm, lateral view; (D) ♀, 13.1 + 4.1 mm, ventral view. Scale bar = 5 mm.

Fig. 5: Obarvanost severnojadranskih primerkov vrste** Lebetus guilleti. **Samec (A) in samica (B) v naravnem življenjskem prostoru. Bolj pisane barve se pokažejo po omamljenju in/ali po shranitvi primerka v formaldehidu: (C) ♂, 12,6 + d mm, pogled s strani; (D) ♀, 13,1 + 4,1 mm, pogled s trebušne strani. Merilo = 5 mm.

plate and last hemal spine, respectively. Ossification of former less in male, notched on dorsal rim. Parhypural and hypural 5 small splint-like bones. Two large hypural plates, hypural 3+4 and hypural 1+2, former fused with urostyle, latter inserting ventral to ural centrum. All fin rays associated with large hypural plates branched. One ray of both dorsal and ventral of those branched rays articulated, but not branched.

Coloration. Within the natural habitat, the body coloration is well adapted to the substrate (Figs. 5a, 5b). Basic coloration is a broad brown and white oblique transverse pattern. Head greyish in males, brownish in females, followed by a white interspace below D1 base. Anterior edge of following brown transverse bar oblique, running from D2 origin to ventral middle of belly. Large bright spot ventrally interrupts this bar in both sexes. Posterior edge at beginning of caudal peduncle curved. Caudal peduncle almost white. Before C origin narrow brown transverse band with oblique anterior edge from dorsal origin of caudal fin to ventral beginning of last quarter of caudal peduncle. Brown pattern dorsally slightly extending on to caudal fin. All brown vertical bars are well separated from white interspaces by dark margins. Proximal half of pectoral fin white, distal half transparent to dusky. C transparent. Sexual dimorphism especially shown in dorsal fin coloration.

Males (Fig. 5a): D1 greyish with yellow oblique bands, one narrow in lower third and one broad in upper third; edged white. D2 edged black, especially with large blotch in upper anterior corner. Six oblique narrow yellow bands below dark edge running across fin rays and separated from one another by dark edges and transparent interspaces. V and A usually dusky. Lips yellow to light orange.

Females (Fig. 5b): D1 white to light grey with a small green eye spot between fifth and sixth fin rays. D2, V and A transparent. Lips red, especially in posterior half.

A more colourful pattern in body coloration is shown when the fish are narcotised, kept in a photographic aquarium or recently preserved in formaldehyde (Figs. 5c, 5d).

Males: When captured, head becomes yellowish with some orange spots on cheek, snout and upper lip light orange. First bright interspace on trunk shows 4 narrow but conspicuous brown to orange-red vertical bands extending on to belly. Middle parts of following brown vertical bar with large red parts. Yellow bands in D1 and D2 and dark edge of D2 become more distinct. A, distal half of V and ventral part of P turn dark grey to black. Proximal half of V red.

Females: Head and broad brown trunk bar with dark red regions. Bands within first white interspace on trunk not distinct, somewhat irregular and coloured light brown with red dots. D1 turns dark grey with two to three slight red bands, eye spot still visible. D2 dusky with 4 red oblique bands. A and distal half of V black.

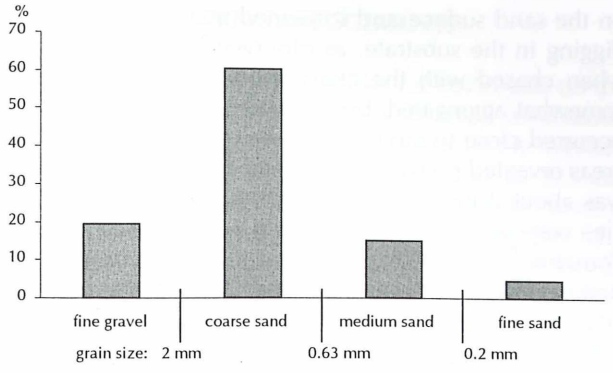

Fig. 6: Grain size distribution of the sediment in the habitat of** Lebetus guilleti **in the northern Adriatic Sea.
Sl. 6: Granulacija sedimenta v habitatu vrste** Lebetus guilleti **v severnem Jadranskem morju.

Breast, proximal half of V and base of A red. P bright with dark spot in centre.

After preservation in 70% ethanol, the specimens retain only brown and black coloration with white interspaces. Females exhibit darker mottling on head, breast and in first dorsal fin. Narrow red bands below D1 get lost or turn light brown. In both sexes, broad brown oblique bar on trunk brightened in centre, therefore mainly represented by dark margins. Brown band on caudal peduncle well visible. Black margin of D2 in males stays distinct. Distal half of V and A in both sexes black. P in males with ventral half dusky, in females with black spot in the centre.

Ecology

All specimens observed and collected were found on a bottom consisting of a highly biogenic coarsely structured sand as shown by the grain size distribution (Fig. 6). The fish were found within a depth range of 6 to 13 m. The shallowest discovery was near Klenovica, Kvarner region, where one specimen was collected at 6 m depth. At Selce, Kvarner region, the specimens occurred frequently at depths between 11 and 13 m, and between 7 and 10 m at Rovinj. The habitats investigated near Rovinj and in the Kvarner region show high similarities, characterised by sandy bottom, which is interrupted by bedrock areas at depths of about 5 to 9 m, dividing the sandy areas into small insular spots. The fish were found in both large areas and in small insular spots of sand bottom. The specimens were discovered accidentally when the anaesthetic was dispersed from a squeeze bottle over the sediment. The tiny fish exhibit a very cryptic behaviour with few movements and high colour adaptation, which makes them almost invisible. The fish can be discovered by a diver when moving one hand forward flowly and directly over the sand surface, which causes flight reactions. The fish appear to dwell

on the sand surface and it seemed quite unusual when digging in the substrate, as observed in one specimen, when chased with the anaesthetic. The distribution is somewhat aggregated, because most specimens usually occurred close to each other, while large neighbouring areas revealed no fish. The highest abundance observed was about 2 ind./m^2. Co-occurring epibenthic fish species were especially *Gobius roulei, Buenia affinis* and *Pomatoschistus bathi,* which dwell on the same substrate in high abundance. All collected specimens are adult and sex determination was possible from coloration, differences in fin shape and the typical sexual dimorphism of the urogenital papillae. Within the material collected only one size class, obviously the one year-class, occurs. The specimens collected in spring range from 10.6 to 14.5 mm SL. This includes the specimen collected in the western Mediterranean by Zander (1982) in June 1979 with 12.9 mm SL. The only collection made in autumn revealed a larger specimen of 17.4 mm SL. Collected at the same time, females are larger than males within this one size class.

DISCUSSION

Since Miller (1971, 1986) suggested two species within *Lebetus* Winther, 1877, due to different postlarval developments of pelvic fins and pigmentation and different meristic values of anal fin, second dorsal fin and vertebrae, the northern Adriatic specimens can be assigned to *L. guilleti* (Le Danois, 1913) (Tab. 2). Counts of fin rays and vertebrae are significantly higher in *L. scorpioides* than in *L. guilleti* and therefore enable identification also of subadult or adult benthic specimens (Miller, 1971). The western Mediterranean specimen found by Zander (1982) at Banyuls (France) exhibited the very typical coloration (Zander, *pers. comm.)* as described above for the northern Adriatic specimens and represents a male *L. guilleti.* The greater number of specimens investigated now increases the knowledge of the morphology of this species and indicates a wider anal fin ray count of I/4-6 (Tab. 2).

Apart from meristics, there are differences between *L. guilleti* and *L. scorpioides* in some specific coloration patterns. In particular, the first dorsal fin in males of the former is less uniformly coloured. The second dorsal fin exhibits more but narrower oblique bands. The dorsal fins are also important for sex discrimination in both species (see also Miller, 1963). Body coloration seems to be more differentiated in *L. guilleti* with vertical bars occurring on the abdomen in both sexes but especially in males. Also the dark bar on the posterior caudal peduncle appears more evident, expanding more anteriorly on ventral side. Nevertheless, the basic coloration patterns of both species is very similar. In osteology, the main differences occur in the number of vertebrae, this being lower in *L. guilleti.* Other features show no major differences. The cleithrum in *L. guilleti* appears straighter in lateral view and somewhat elongated on its bifid dorsal end. The caudal skeleton appears less strong, with the roots of the neural and hemal spine expanding over entire length of vertebral centra only in the last vertebra.

Similarities of the genus *Lebetus* with other Mediterranean gobies relate mainly to *Speleogobius trigloides* Zander and Jelinek, 1976. Although there is an anterior oculoscapular head canal developed in the latter, the arrangement of the superficial head sensory papillae is very similar (compare with Zander & Jelinek, 1976; Miller, 1986). Meristics of fin rays and scales are almost the same as those of *L. guilleti.* As predorsal scales are only present in *S. trigloides, Lebetus* may be regarded as more specialised by reduction of squamation. In both the anterior membrane of the ventral disc is lost. They also conform in small body size and in a conspicuous colourful body coloration, which can be suppressed by *Lebetus* due to substrate adaptation. These similarities suggest a close relationship and possible common ancestry for *Speleogobius* and *Lebetus,* with some features more generalised in the former.

Affinities of the genus *Lebetus* with different 'sand-goby' genera *(Pomatoschistus, Gobiusculus, Knipowitschia* and *Economidichthys)* and related genera are described by Miller (1963) and McKay & Miller (1997). High similarities are exhibited with *Buenia* Iljin by the arrangement of head sensory papillae and meristic counts, although the latter being lower in *L. guilleti.* Both genera conform in a very limited number of head neuromasts basically arranged longitudinally and in dwelling sand bottom. *Buenia* is more generalised in possessing a complete head canal system. Further differences exist in the dorsal pterygiophore formula, being derived with 1221 in *Buenia,* and in higher variations in the counts of precaudal and caudal vertebrae in *Lebetus* (McKay & Miller, 1997).

Concerning the ecology of *L. guilleti* in the northern Adriatic Sea, several observations confirm the results of Zander (1982) and Miller (1971) in the western Mediterranean Sea and northern Atlantic. Both the habitat choice of rough biogenic sand bottom and the co-occurrence of *Pomatoschistus bathi* in high abundance correspond with Zander (1982). The substrate inhabited by the small population near Rovinj, where about six specimens were observed during one dive, resembles that off Selce. Highly biogenic coarse sand is interspersed with large rocky boulders. The habitat choice of coarse deposits and the occurrence in quite shallow waters were also described by Miller (1971) for the north-eastern Atlantic specimens. In contrast to *L. scorpioides* from the north-east Atlantic, which is supposed to mature in the second year of life (Miller, 1963), *L. guilleti* seems to attain sexual maturity within the first year of life in the Mediterranean. Since the one year

class, represented by only tiny specimens collected in the Mediterranean until now, appears to be the only size class, a semelparous reproductive strategy is possible. The very small size of this fish within the Mediterranean may explain why this species had not been found in that region for such a long time.

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LEBETUS GUILLETI (TELEOSTEI: GOBIIDAE): PRVI ZAPIS TE VRSTE IZ SEVERNEGA JADRANSKEGA MORJA IN PODATKI O NJENI MORFOLOGIJI

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POVZETEK

Avtorji članka poročajo o prvem opazovanju vrste Lebetus guilleti *(Le Danois, 1913) iz družine glavačev v obalnih vodah severnega Jadrana. Leta 1999 in 2001 so v Kvarnerju južno od Reke dokumentirali osem samic (SL 12,1-17,4 mm) in pet samcev (SL 10,6-12,5 mm) na peščeni podlagi v globinah med 6 in 13 metri. Druga manjša populacija te vrste je bila fotografirana maja 2002 ob istrski obali v bližini Rovinja. Zbrani osebki so pripadali vrsti* L. guilleti *(Le Danois, 1913), kar je bilo ugotovljeno po njihovih naslednjih značilnostih: majhno telo, specifična barva telesa, popolnoma brez bočnih naglavnih kanalov, obstoj podočesnega niza a, omejeno število naglavnih čutilnih papil z dvema medočesnima nizoma, podaljšani žarki hrbtne plavuti in meristične vrednosti D2 I/7-8, A I/4-5, P 14-15, LL 24-26 in VC 25-26. Ta nedavna odkritja so omogočila natančnejši opis morfologije te malo znane vrste. Avtorji podajajo njene morfometrične podatke, meristične vrednosti, parametre v zvezi s pobočnico, obarvanost, skeletne značilnosti in ekologijo in* L. guilleti *primerjajo s sorodnimi rodovi glavačev.*

Ključne besede: Gobiidae, *Lebetus guilleti*, Sredozemlje, severno Jadransko morje

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ZAVAROVANA OBMOČJA

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A TOPOGRAPHICAL SURVEY OF HABITAT TYPES IN THE AREA CHARACTERIZED BY SEAGRASS MEADOW OF *POSIDONIA OCEANICA* IN THE SOUTHERN PART OF THE GULF OF TRIESTE (NORTHERN ADRIATIC)

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ABSTRACT

According to the national legislation and by considering international documents on nature conservation, the Mediterranean endemic seagrass Posidonia oceanica *was included in the latest edition of the Slovenian Red List of Rare and Endangered Species. Moreover, the only Slovenian site with* Posidonia oceanica, *which is also the only meadow along the West Istrian coast, was proposed to be declared a natural monument in 1994. However, besides some preliminary data on the topography and phenology of the meadow, very few data are available regarding its fauna and flora. Being an area of great conservation interest, a non-destructive underwater inspection has been carried out. The floristic and faunistic data, together with accurate habitat type cartography, are presented. A special emphasis was given to ichthyofauna.*

Key words: *Posidonia oceanica*, North Adriatic, topographical survey, nature conservation, non-destructive methods

RILIEVO TOPOGRAFICO DEI TIPI DI HABITAT NELL'AREA CARATTERIZZATA DA UNA PRATERIA DI *POSIDONIA OCEANICA* NELLA PARTE MERIDIONALE DEL GOLFO DI TRIESTE (NORD ADRIATICO)

SINTESI

Recentemente è stata inoltrata la proposta per dicharare l'unico sito in cui ancora cresce una prateria di Posidonia oceanica *in acque slovene Monumento Naturale, vista la sua unicità e vulnerabilità. Fino ad oggi la fauna e la flora della zona non sono state studiate a sufficienza. Vista l'imminente dichiarazione ufficiale del sito ad area protetta, per il presente studio è stato usato un metodo di campionamento subacqueo non distruttivo. L'articolo riporta i dati faunistici e floristici, nonché un'accurata cartografia dei tipi di habitat della zona. L'ittiofauna ha occupato un posto di rilievo nella ricerca.*

Parole chiave: *Posidonia oceanica*, Alto Adriatico, rilievo topografico, tutela della natura, metodi non distruttivi

INTRODUCTION

Posidonia oceanica (L.) Delile is an endemic seagrass species in the Mediterranean. It forms seagrass meadows, which are nowadays considered to be amongst the most important habitat types in the infralittoral zone of the Mediterranean Sea. Seagrass beds are known to be key nursery areas for coastal fisheries. According to some authors, the presence of *P. oceanica* should be also regarded as a good biological indicator of water quality due to its sensitivity to human activities (*sensu* Piazzi *et al.*, 2000). The isolated *P. oceanica* meadow in Slovenian coastal waters, between the towns of Izola and Koper (referred hereafter as the Koper meadow), was described by Vukovič (1982). Besides the tiny patch of app. 2 m^2 close to Grado, it seems that the Koper meadow is the only remnant of this marine phanerogam in the Gulf of Trieste and along the Istrian coast. According to Benacchio (1938), *P. oceanica* was quite common on the silted bottom of the inner part of the Gulf of Trieste. However, a drastic reduction in its distribution was recorded just about 30 years later by Simonetti (1966) in his work dealing with distribution of the Zosteraceae in the Gulf.

Although no specific mapping programme for seagrass meadows has been made in Slovenia so far, some data are available on different aspects of the distribution (Vukovič & Turk, 1995) and phenology (Turk & Vukovič, 1998) of *P. oceanica* as well as on epiphytes and its colonisation (Orlando & Bressan, 1998). Some data are also at hand on the impacts of motorway pollution on the ecological conditions of the site (Faganeli *et al.*, 1997). One of the most interesting aspects of the Koper meadow – the possibility of being an ancient, post-glacial clone – is described in the work on genetic identity and homozygosity in Northern Adriatic populations of *P. oceanica* carried out by Ruggiero *et al.* (2002).

A decree for the protection of the meadow is being currently drafted by the government. The most important aspect of biodiversity is species composition, a checklist of a variety of species present in the area (Costello, 2000). To assess the marine biodiversity of a protected site, a non-destructive methodology is more suitable than any other classical sampling technique. Almost 50 years have passed from the inception of the non-destructive underwater visual census technique (Brock, 1954) for the study of coral reef fish assemblages. Numerous studies throughout the world confirmed the usefulness of this technique, which is nowadays accepted as a useful methodology to gain coastal fish density estimate (Harmelin, 1987; Francour, 1991, 1994; Harmelin-Vivien & Francour, 1992; Patzner & Serrao Santos, 1993; Harmelin *et al.*, 1995; Castellarin *et al.*, 2001). Today, visual census data are recognised as a valuable source of information for other aspects of fauna (Peharda *et al.*, 2000), flora, habitat types and in broader meaning for conservation purposes as well (Edgar *et al.*, 2000).

The present study aims to describe the habitat types occurring in the proposed protected area covered with *P. oceanica* seagrass meadows, and to assess the faunistic and floristic diversity of the area with non-destructive methods. Since this area is to be legally protected, such data can be very useful in the process of defining suitable conservation measures.

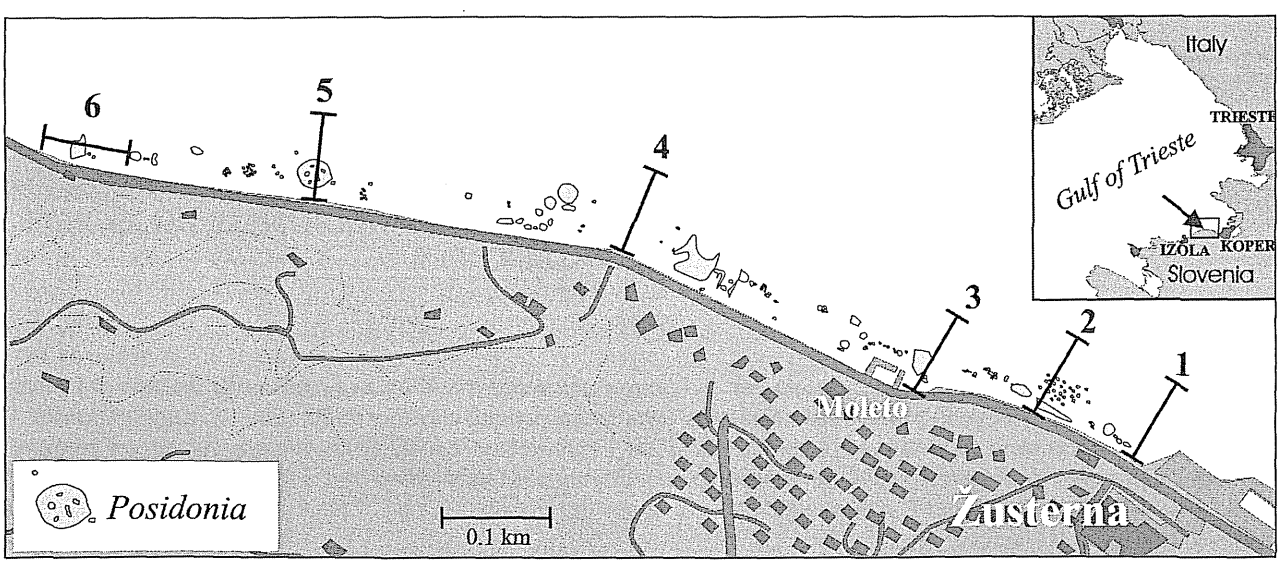


Fig. 1: Location of transects in the proposed natural monument area near Koper.
Sl. 1: Lokacije transektov na predlaganem naravnem spomeniku blizu Kopra.

MATERIAL AND METHODS

Study area

The study area is located between the towns of Izola and Koper, with the only site of *P. oceanica* seagrass meadow along the northern and western coasts of Istria. As a recent sediment of Koper Bay it consists of sandy silt with up to 40% of sand and less than 15% of clay (Ogorelec *et al.*, 1988).

The area surveyed is a known tourist resort with many recreational facilities. This is particularly true of the eastern part, which is close to the city of Koper and densely inhabited, whereas towards the city of Izola in the west the area is without any man-made structures but for the waterfront once used by the railway. On the other hand, the area has been subjected to a certain extent to organic pollution from the nearby city of Koper. Although recent studies have shown benthic organisms contaminated with PAH and heavy metals, this has not been reflected in the area's benthic community (Faganeli *et al.*, 1997).

Material and methods

Taking into account the vulnerability of the area, the underwater inspection of the area's flora, fauna and habitat types was carried out by SCUBA divers in the summer of 2000 and in the summer and autumn of 2001 along five vertical transect lines (station 1-5). The distances between different stations are shown in Fig. 1. During each survey we tried to get as much data as possible on the flora, fauna, habitat types and cryptobenthic fishes. A special emphasis was laid on the underwater mapping of different habitat types, occurring along the transect lines. Details about sighted animals and algae were written on a slate. Only the specimens, which were not determined during the sampling, were taken out in special bags and identified later in the laboratory and subsequently released. Only epifauna was taken into consideration.

For the assessment of coastal fish assemblage, a visual census technique was performed by two SCUBA divers along 60 m long transects. Coastal fish were counted up to 2 meter away from the transect rope by one or two divers. Two 30-m long measuring tapes were used. The average duration of a visual count transect was approximately 20 minutes. Additionally we used the data of one parallel census in *P. oceanica* habitat type at the station 6. In addition, a narcotiser quinaldin (MS222) was used to detect some cryptobenthic fish species, which could be otherwise overlooked.

Habitat type cartography was carried out by filming with underwater Sony camera (Handicam Hi-8). The diver with the camera followed the transect rope and filmed all habitat types. Afterwards, some shots of specific vegetation cover or peculiar habitat types in the neighbouring area were taken as well. Additionally, some specific habitat types were photographed with Subeye underwater camera. In the laboratory the transect films were carefully analysed and used for drawing habitat types. The coverage of each habitat type was estimated by calculating the area in habitat type distribution drawings.

RESULTS AND DISCUSSION

Floristic survey

At least 58 algal species and 2 other phanerogams (*Cymodocea nodosa* and *Zostera noltii*) were recorded in the investigated area (Tab. 1). Altogether 10 green macroalgae, 11 brown macroalgae and 37 red macroalgae were recorded. Twenty-four epibionts had been previously surveyed by Orlando & Bressan (1998).

The vegetation cover in the area is strongly connected with the ecological conditions, such as the water quality and the seabed substrata. In somehow deeper area, the seabed is covered by sandstone rocks and cobbles, which are not suitable for algae, and by some bigger boulders, to which *Alsidium corallinum* and *Anadyomene stellata* are attached.

Faunistic survey

Benthic invertebrate fauna

At least 88 taxa of benthic invertebrates were recorded in the studied area (Tab. 2). The majority of them, 38 species, were mollusks, followed by crustaceans (16), sponges (8), cnidarians (7), echinoderms (6), polychaets (6), tunicates (4) and bryozoans (3). At the station 1, at least 45 species were recorded, whereas at stations 2 and 3 at least 58 species were sighted. The invertebrates recorded were found mostly as fauna on rocks and boulders or as epibionts on *Posidonia*, *Cymodocea* and *Cystoseira*. The number of animals recorded is obviously far from complete, since only epifauna was taken into consideration. On the other hand, we used the technique of visual inspection mostly as it is a non-destructive method and at the same time very appropriate for protected areas. Many tiny and cryptic invertebrates could obviously not be recorded with such method.

Numerous studies demonstrated the importance of *Posidonia* seagrass meadows for a variety of animal groups. It is characterized as a complex biotic community with high richness, in which many animals spend all or part of their lives (*sensu* Garcia-Raso, 1990). According to Somaschini *et al.* (1993), the polychaete community of the *P. oceanica* bed is richer and more diversified than the neighbouring environment.

***Tab. 1*: Checklist of the flora associated with *Posidonia oceanica* seagrass meadow in the Žusterna-Moleto region (Legend: M = macroalgae, E = epiphyte, C = seagrass, Me = mediolitoral, Z Me = upper mediolitoral, S Me = lower mediolitoral, I = infralittoral, Z I = upper infralitoral, S I = lower infralitoral).**

Tab. 1: Popis flore, povezane s travniki morske trave pozejdonke na območju med Moletom in Žusterno (Legenda: M = makroalge, E = epifit, C = morska trava, Me = mediolitoral, Z Me = zgornji mediolitoral, S Me = spodnji Mediolitoral, I = infralittoral, Z I = zgornji infralitoral, S I = spodnji infralitoral).

TAXON		Belt
Alsidium corallinum	M	I
Anadyomene stellata	M	I
Antithamnion tenuissimum	E	I
Ascocyclus orbicularis	E	I
Callithamnion corymbosum	E	I
Ceramium sp.	M + E	I
Ceramium cingulatum	E	I
Ceramium circinnatum	E	I
Ceramium tenerrimum	E	I
Chaetomorpha sp.	M + E	Me
Chylocladia sp.	E	I
Chylocladia verticillata	E	I
Chondria dasyphilla	M	I
Cladophora sp.	M	I
Cladophora echinus	E	I
Cladophora prolifera	M + E	S Me + I
Cladosiphon cylindricus	E	I
Cladostephus verticillatus	M	Me + I
Corallina granifera	M + E	Z I
Corallina officinalis	M	Z I
Cymodocea nodosa	C	I
Cystoseira barbata	M	I
Cystoseira compressa	M	I
Dictyota dichotoma	M	Z I
Dictyopteris membranacea	M	S Me + Z I
Erithrotrichia carnea	E	I
Fucus virsoides	M	Z Me
Gelidiella nigrescens	M + E	I
Gelidium sp.	M + E	I
Gelidium spathulatum	M	I
Gigartina sp.	M	I
Giraudya sphacelarioides	E	I
Halopithys incurvus	M	Z I
Heterosiphonia wurdemannii	E	I
Hydrolithon cruciatum	E	I
Hydrolithon farinosum	E	I
Laurencia obtusa	M	S Me +I
Laurencia papillosa	M	Z I
Lophosiphonia scopulorum	E	I
Nitophyllum punctatum	M	Z I
Padina pavonica	M	S Me + I
Peyssonnelia squamaria	M	S I
Pneophyllum fragile	E	I
Polysiphonia denudata	E	I
Polysiphonia furcellata	E	I
Polysiphonia nigrescens	E	I
Posidonia oceanica	C	I
Pseudolithophyllum expansum	M	S I
Pterocladia capillacea	M	S Me + I
Sphacelaria cirrhosa	M	I
Spyridia filamentosa	M + E	I
Stylonema alsidii	E	I
Titanoderma corallinae	E	I
Titanoderma pustulatum	E	I
Udotea petiolata	M	S I
Ulva sp.	M + E	S Me + I
Ulva rigida	M + E	S Me + I
Ulvella setchellii	E	I
Valonia utricularis	M + E	I
Wrangelia penicillata	M + E	I
Zostera noltii	C	I

Tab. 2: Checklist of benthic invertebrates recorded in the area during the study period.

Tab. 2: Seznam bentoških nevretenčarjev, opaženih na obravnavanem območju v obdobju vzorčevanja.

Porifera
- *Chondrosia reniformis*
- *Chondrilla nucula*
- *Clione celata*
- *Hippospongia communis*
- *Oscarella lobiformis*
- *Spirastrella cunctathrix*
- *Tethya aurantium*
- *Verongia aerophoba*

Cnidaria
- *Actinia equina*
- *Aiptasia mutabilis*
- *Anemonia sulcata*
- *Balanophyllia italica*
- *Cladocora caespitosa*
- *Eudendrium* sp.
- *Paranemonia cinerea*

Mollusca
- *Aplysia punctata*
- *Aporrhais pes pelecani*
- *Arca noae*
- *Astraea rugosa*
- *Bittium reticulatum*
- *Cerithium rupestris*
- *Cardium edule*
- *Chiton olivaceus*
- *Chlamys varius*
- *Dendrodoris limbatus*
- *Elysia timida*
- *Epitonium communis*
- *Gastrochaena dubia*
- *Gourmya vulgata*
- *Haliotis lamellosa*
- *Hinia costulata*
- *Hinia reticulata*
- *Hinia incrassata*
- *Lima hians*
- *Littorina neritoides*
- *Lithophaga lithophaga*
- *Loripes lacteus*
- *Monodonta articulata*
- *Murex brandaris*
- *Mytilus galloprovincialis*
- *Mytilaster minimus*
- *Ostrea edulis*
- *Patella caerulea*
- *Pholas dactylus*
- *Pinna nobilis*
- *Sepia officinalis*
- *Solecurtus strigillatus*
- *Thuridilla hopei*
- *Truncullariopsis trunculus*
- *Venerupis decussata*

Venus verrucosa
Vermetus triqueter
Polychaeta
Bispira sp.
Protula tubularia
Pomatoceros triqueter
Serpula vermiformis
Spirographis spallanzani
Spirorbis pagenstecheri
Crustacea
Alpheus sp.
Anilocra physodes
Balanus sp.
Carcinus aestuari
Callianasa stebbingi
Chthamalus stellatus
Eriphia spinifrons
Galathea sp.
Ligia italica
Maia verrucosa
Macropodia rostrata
Mysidae
Pinnotheres sp.
Porcellana platycheles
Upogebia littoralis
Bryozoa
Membranipora mebranacea
Electra posidoniae
Schizoporella sanguinea
Echinodermata
Amphipholis squamata
Cucumaria elongata
Holothuria tubulosa
Ophiothrix cf. *fragilis*
Paracentrotus lividus
Sphaerechinus granularis
Tunicata
Ascidia sp.
Diplosoma spongiiforme
Microcosmos cf. *sulcatus*
Phallusia fumigata

Ichthyofauna

At least 33 coastal fish species were found to inhabit the studied area (Tab. 3). The number of species per transect varied from 9 to 22. Only 5 species were recorded at all transects. The majority of species (10) recorded were gobiids, followed by blennioids (8), sparids (6) and labrids (4). The dominant species were *Atherina* sp., *Symphodus roissali* and *S. cinereus*. In the patches of *Posidonia* meadow, only juvenile specimens of *Diplodus* spp. were abundant.

On the basis of a visual count, the highest density was recorded for *Symphodus roissali* with 9.8 specimens per 100 m^2, followed by *S. cinereus* with 3.08 per 100 m^2. However, it must be noted that the 60 m parallel census was carried out in the area, where almost 25% of the habitat type consisted of *Cystoseira* spp.

The dominant gobiid species were ascribed to the *Gobius xanthocephalus/fallax* group. Although the yellow markings on the head typical of the species *G. xanthocephalus* were quite distinct, we decided to use, for practical purposes, the group taxon, since the taxonomical differentiation during the inspection of the transect is almost impossible in the area, where this species is sympatric with other similar gobiids.

Small cryptobenthic fishes *Lepadogaster candollei, Zebrus zebrus* and *Millerigobius macrocephalus* were found in the *Posidonia* meadow (Tab. 3). As they were found under stones, they are not directly related to seagrass meadows. The goby *M. macrocephalus* has been till now recorded only at few sites in the Adriatic Sea (see Jardas, 1996).

In comparison with other areas in Slovenian coastal waters, the studied area is poor. Fifty-two fish species were recorded for Cape Madona Natural Monument, 49 for Strunjan Nature Reserve and 36 for Debeli rtič Natural Monument (Lipej & Orlando Bonaca, *in prep.*). The main reason for this lies in the fact that the data for other areas were obtained by the use of 90 m long vertical transects, due to which a broader variety of different habitats was obtained, which obviously affected the number of species. It is well known that the spatial heterogeneity is an important factor, which affects the species diversity of the area.

If we take into consideration only the seagrass meadow of *P. oceanica,* then only few species can be considered true residents of this area. Bussotti & Guidetti (1999) studied the fish communities associated with *P. oceanica* on the one hand and *Cymodocea nodosa* and *Zostera noltii* seagrass meadows on the other with the visual census technique monthly in August 1995 and August 1996 and never sighted more than 24 fish species. Bell & Harmelin-Vivien (1982) reported 49 fish species on *Posidonia* meadows with a trawl at a depth 16-18 m. However, only 30 species of them were considered to be residents. The depth obviously had an effect on the species number as well. According to the study of Guidetti (2000) on the visual census data in the southern Adriatic, only three species, *Spondylliosoma cantharus, Diplodus annularis* and to a minor extent *Symphodus ocellatus,* were associated with *P. oceanica.*

Since the number of samplings performed in the studied area is lower than in the other (above mentioned) three protected areas in Slovenian coastal waters, we can speculate that the number of species will increase with a further inspection of the area.

Tab 3: Coastal fish assemblage in the studied area. The abundance of different fish species are presented in ranges: - = no specimen recorded, 1 = single specimen, 2 = 2-3 specimens, 3 = 3-5 specimens, 4 = 5-10 specimens and 5 = more than 10 specimens. Cryptobenthic species, which were recorded with the use of narcotic, are marked with asterisk.

Tab. 3: Obrežna ribja združba na obravnavanem območju. Številko osebkov posameznih ribjih vrst je predstavljeno v rangih: - = noben osebek zabeležen, 1 = osebek, 2 = 2-3 osebki, 3 = 3-5 osebkov, 4 = 5-10 osebkov in 5 = več kot 10 osebkov. Kriptobentoške vrste vrste rib, ki smo jih potrdili z uporabo narkotičnega sredstva, so označene z zvezdico.

Št.	Species/ station (transects)	4	5	6	1	3
1	*Atherina sp.*	5	5	5	-	-
2	*Diplodus annularis*	-	1	3	-	2
3	*Diplodus puntazzo*	-	1	-	-	-
4	*Diplodus sargus*	-	1	-	-	1
5	*Diplodus vulgaris*	1	1	3	1	3
6	*Gobius cobitis*	1	1	-	-	-
7	*Gobius cruentatus*	1	1	1	1	1
8	*Gobius paganellus*	1	-	-	-	-
9	*Gobius fallax/xanthocephalus*	-	1	-	3	5
10	*Gobius niger*	-	1	-	1	3
11	*Gobius roulei*	-	1	-	-	-
12	*Lepadogaster candollei**	-	1	-	-	-
13	*Lipophrys adriaticus*	-	-	-	1	-
14	*Lipophrys dalmatinus*	4	4	-	-	-
15	*Millerigobius macrocephalus**	-	1	-	-	-
16	*Oblada melanura*	3	3	-	-	-
17	*Parablennius gattorugine*	1	-	-	-	1
18	*Parablennius incognitus*	2	-	-	-	1
19	*Parablennius rouxi*	-	1	-	-	-
20	*Parablennius sanguinolentus*	-	-	-	2	-
21	*Parablennius tentacularis*	1	1	-	-	-
22	*Pomatoschistus marmoratus*	-	-	-	-	5
23	*Sarpa salpa*	-	-	1	-	5
24	*Serranus hepatus*	1	-	-	-	3
25	*Serranus scriba*	2	2	2	2	-
26	*Symphodus cinereus*	2	3	5	3	5
27	*Symphodus ocellatus*	3	3	1	3	2
28	*Symphodus roissali*	5	5	5	3	2
29	*Symphodus tinca*	2	2	-	2	-
30	*Syngnathus acus*	1	-	-		
31	*Tripterygion tripteronotus*	2	-	-	-	-
32	*Zosterissesor ophiocephalus*	1	-	-	-	-
33	*Zebrus zebrus**	-	2	-	5	-
	Total number of species	19	22	9	12	14

Habitat types

The studied area is characterised by several different habitat types such as allochthonous limestone boulders, photophilic algal population on rocks and boulders, sandstone terraces, *C. nodosa* meadow, *P. oceanica* meadow, as well as muddy sands and mud (Fig. 2). The coverage of each habitat type at different transects is shown in Table 4. The comparison between five transects showed quite different habitat type distribution, although the distance between the 1st transect and the 5th transect was below 1 km. *Posidonia oceanica* was recorded as a patch or just with a few shoots. This again confirms the sporadic distribution of *Posidonia meadows sensu* leopard spot pattern. Station 1 was characterized by reduced water column transparency, which may have also an impact on the *Posidonia* distribution (Meinesz *et al.*, 1988).

Although the *C. nodosa* is present at all five vertical transects, its distribution is very diverse. Along transect 5

Tab. 4: Habitat type distribution (expressed as percentage of the entire surveyed transect area) along five transects. The term fine sand indicates the area not covered by vegetation.
Tab. 4: Razporeditev habitatnih tipov: apnenčasti balvani, terase peščenjaka, travnik cimodoceje, travnik pozejdonke, fini pesek, mulj, prodnjaki in infralitoralni kamni in skale (izraženih v odstotkih celotne površine pregledanega območja) na 5 transektih. Z izrazom fini pesek označujemo predele, ki niso bili poraščeni z vegetacijo.

Habitat type/stations (transects)	1	2	3	4	5
Allochthonous boulders	7.50	5.0	10.0	11.67	12.50
Sandstone terraces	0	0	21.67	7.50	0
Cymodocea meadows	33.33	13.33	18.33	8.33	26.67
Posidonia meadows	0	11.67	2.50	0.80	52.50
Fine sand*	0	22.50	28.33	45.83	4.20
Mud	22.50	15.00	0	0	0
Pebbles	10.83	5.83	13.33	12.50	4.20
Infralittoral stones and rocks	25.83	20.83	5.83	13.33	0.0

spreads a dense meadow, whereas in other transects the density is very low. It seems that the ecological conditions are not the same at the five studied transects.

Limestone boulders

Allochthonous limestone boulders were placed along the coastal trunk road to function as wavebreakers. Numerous niches are available on these boulders and between them, which has resulted in typical mediolittoral fauna and flora. A broad and large belt on the allochthonous limestone boulders is covered by the association *Fucetum virsoidis*, represented by *Fucus virsoides*. Characteristic of this belt are also some other common species, such as *Chaetomorpha linum, Padina pavonica, Cladophora prolifera, Cladostephus verticillatus, Dictyopteris membranacea,* and *Ulva rigida*. The last two also form the typical nitrophilic associations *Dyctiopteretum membranaceae* and *Pterocladio–Ulvetum*, which normally develop in areas influenced by organic pollution.

Pebbles

Pebbles of irregular shapes were found at all 5 studied transects. Due to the constant wave action, they are not overgrown with vegetation. However, at all transects benthopleustonic alga *Ulva rigida* was found as very abundant. This nitrophilous green alga is probably connected with outlets of sewage water from the nearby tourist resort Žusterna.

Most species inhabiting this area are hidden under pebbles. The typical fish species of this habitat type are *Gobius paganellus, G. cobitis* and *Parablennius sanguinolentus*.

Photophilous algae

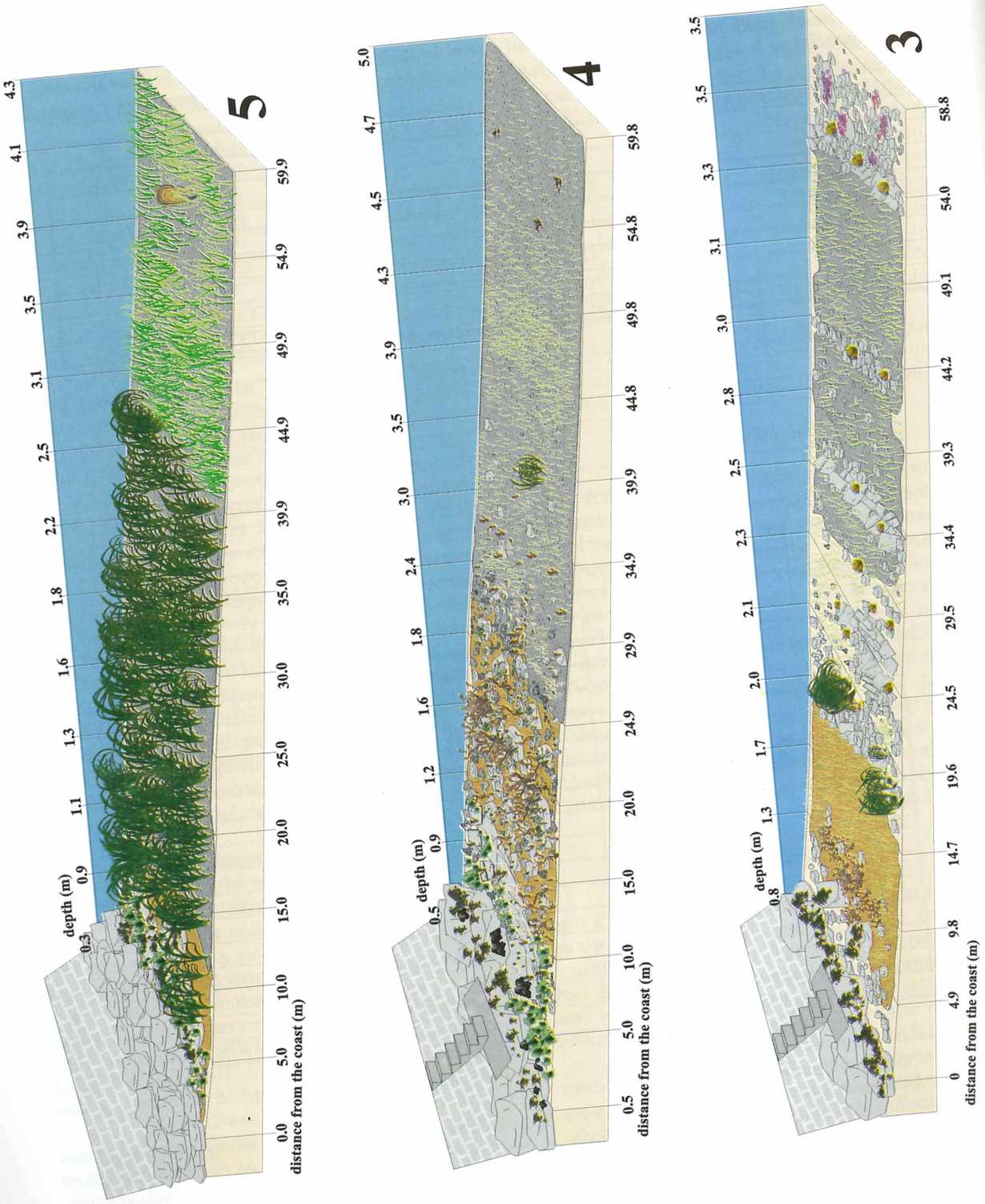
Other parts of the infralittoral belt are covered with dense algal phytal consisting mainly of *Cystoseira compressa* and C. *barbata*, which are inhabited by some epiphytes such as: *Corallina granifera, Ceramium* sp., *Gelidium* sp., *Polisiphonia furcellata, Spyridia filamentosa, Ulva rigida, Valonia utricularis*. On such substrata, *Halopithys incurvus, Laurencia papillosa* and *L. obtusa, Wrangelia penicillata, Dictyota dichotoma* are commonly distributed as well. In this habitat type, the majority of fishes occurred. Some boulders can be found at somewhat greater depth, forming substrata for dense algal cover and different sponges, sea anemones, vermetid snails and other molluscs. Wrasses such as *Symphodus roissali* and *S. cinereus* predominated in the fish assemblage of this particular habitat type.

Boulders are also inhabited by different fish species, which are using shelters made by endolithic bivalves such as *Lithophaga lithophaga* or live in the boulders' cracks and crevices. The majority of them are blennies *(Lipophrys dalmatinus, Parablennius incognitus)* and gobies *(Gobius cf. xanthocephalus, Zebrus zebrus)*.

Posidonia meadow

In the transition zone, the patches of *P. oceanica* are situated between stony coastline and mud at a depth interval of 0.5 m to 4 m. The area is approximately 1 km long and 50 m wide (Fig. 1), with the maximum depth between 2 and 4 m. It shows patchy distribution, e.g. it is restricted to small islets ("leopard spots") (Vukovič, 1982; Vukovič & Semroud, 1984; Vukovič & Turk, 1995), embraced by *C. nodosa*. The *Posidonia* shoot density varies between 360 and 588 shoots/m^2, or 460 shoots/m^2 on average (Turk & Vukovič, 1998).

In the shady parts of the *Posidonia* shoots or stones some rhodophycean algae such as *Pseudolithophyllum expansum* and *Peyssonnelia squamaria*, which are typical of coralligenous formations, were recorded. Only few fish species were sighted in this habitat type, but with the use of quinaldine we detected some interesting cryptobenthic species, such as *Millerigobius macrocephalus* and *Lepadogaster candollei*.


5
depth (m)
0.3 0.9 1.1 1.3 1.6 1.8 2.2 2.5 3.1 3.5 3.9 4.1 4.3
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 39.9 44.9 49.9 54.9 59.9
distance from the coast (m)
4
depth (m)
0.5 0.9 1.2 1.6 1.8 2.4 3.0 3.5 3.9 4.3 4.5 4.7 5.0
0.5 5.0 10.0 15.0 20.0 24.9 29.9 34.9 39.9 44.8 49.8 54.8 59.8
distance from the coast (m)
3
depth (m)
0.8 1.3 1.7 2.0 2.1 2.3 2.5 2.8 3.0 3.1 3.3 3.5 3.5
0 4.9 9.8 14.7 19.6 24.5 29.5 34.4 39.3 44.2 49.1 54.0 58.8
distance from the coast (m)

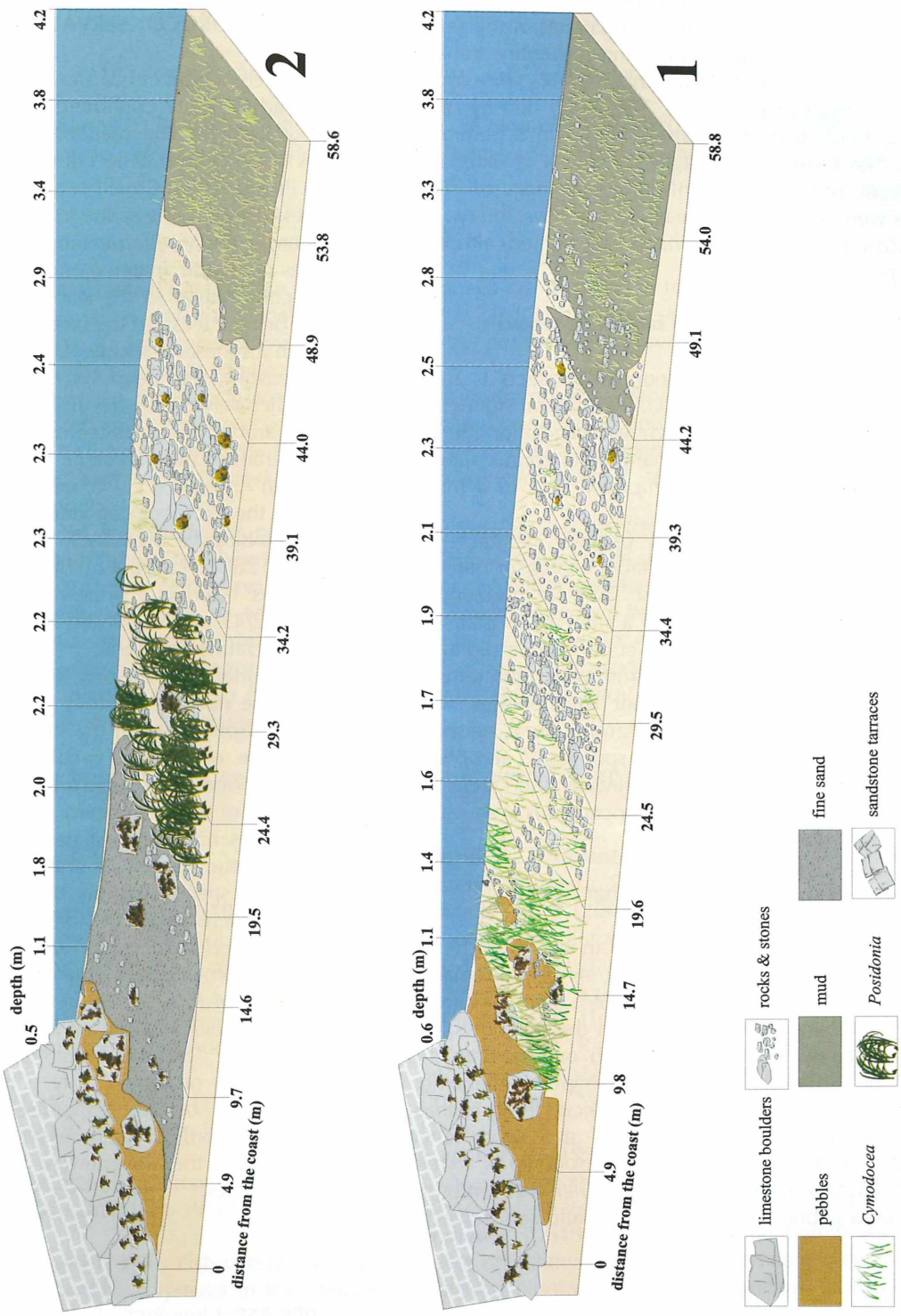


Fig. 2: Habitat type distribution at 5 linear transects in the study area (see Fig. 1).
Sl. 2: Razporeditev habitatnih tipov na 5 linearnih transektih na obravnavanem območju (glej tudi Sl. 1).

Cymodocea meadow

Close to the coast is also the *C. nodosa* seagrass meadow, occurring either in small patches in the sandy area or almost completely covering the entire transect area. A low number of *Zostera noltii* plants were found intermingling with *C. nodosa*. The mean density of *C. nodosa* shoots was 69 shoots/m^2 (Vukovič & Semroud, 1984). The *Cymodocea* seagrass meadow is extending to a depth of 6 to 8 m. Only few specimens of *Pinna nobilis* were found. In this seagrass meadow, the typical goby *Zosterissesor ophiocephalus* was sighted, although it was not abundant.

"Naked" boulders and sandstone terraces

These habitat types were found at transects 1, 2 and 3 between Moleto and Žusterna. Infra-littoral stones and boulders were poorly overgrown with vegetation (the so-called algal turf). The dominant invertebrate species were the sponge *Verongia aerophoba* and, to a minor extent, *Cladocora caespitosa*.

Sandstone terraces form a peculiar habitat type, which provides a number of suitable niches for different invertebrates and littoral fishes. They lie horizontally and thus give an impression of a man-made platform. The terraces are overgrown with corraligenous red algae *Pseudolithophyllum expansum*, from which the terraces obtained their colour. Dominant invertebrates were polychaets of the genera *Protula* and *Serpula*, vermetid gastropod *Vermetus triqueter* and sponges *V. aerophoba* and *Chondrilla nucula*. In little crevices and cracks between terraces, *Gobius* cf. *xanthocephalus* was established as the dominant littoral fish.

Sandy and muddy habitat types

Some species were sighted only in sandy patches or at the end of transects, where the stony bed is replaced by mud. In these peculiar habitat types, more specimens of *Pinna nobilis* were found than in the meadows, but the majority of them were dead. In our opinion, this should be attributed mainly to the high sedimentation rate in this area. The typical sand species *Pomatoschistus marmoratus* was found on sand at a depth range from 2 to 4 m between patches of *Posidonia* or *Cymodocea* seagrass meadows. *Gobius roulei*, a recently rediscovered gobiid species in the Adriatic sea (Kovačić, 1995), was more or less restricted to coarse sand, whereas *G. niger* preferred muddy areas.

NATURE CONSERVATION VALUE

The different aspects of the importance of *P. oceanica* meadows were confirmed in the last decades by numerous authors. The meadows are the base of the richness of the coastal waters of the Mediterranean (Molinier & Picard, 1952; Cinelli *et al.*, 1974; Boudouresque & Meinesz, 1982). This is due to the great surface of the sea bottom of the Mediterranean they cover, to the great quantities of organic material and oxygen they produce, to their contribution to the stability of the sea bottom and, last but not least, to the fact that the meadows host more than a thousand species of marine organisms. For all this reasons, the meadows of *P. oceanica* and the species themselves are legally protected in several countries around the Mediterranean. Besides, the contracting parties to the Barcelona convention included *P. oceanica* in Annex II – List of endangered or threatened species of the Protocol concerning specially protected areas and biological diversity in the Mediterranean (see Lipej *et al.*, 2000). Last but not least, the meadows of *P. oceanica* are listed as a priority habitat type in the EU Directive 92/43 on the conservation of natural habitats and on wild fauna and flora.

The importance of the tiny Koper meadow and consequently the need for a strict protection go even beyond the reasons listed in the previous paragraph. The total absence of genetic variability in the meadow, stated in the work by Ruggiero *et al.* (2002), is another strong cause of major concern for conservation of the species in this northernmost part of the Adriatic. Low levels of genetic variability and habitat fragmentation can influence species fragility by lowering populations resilience to increasing levels of ecosystem disturbance, either of anthropogenic origin or not (Meffe & Carroll, 1997). Legal protection of the Koper meadow as the only remnant of *P. oceanica* in the Gulf of Trieste and introduction of efficient conservation measures, together with a suitable long-term monitoring, should be regarded as issues of high priority. The regression of the meadow would not only jeopardise the survival of the species in the North Adriatic but would also add a hundred or more to the Slovene Red Lists of rare and endangered species.

TOPOGRAFSKI PREGLED HABITATNIH TIPOV NA OBMOČJU RASTIŠČA POZEJDONKE, *POSIDONIA OCEANICA*, V JUŽNEM DELU TRŽAŠKEGA ZALIVA (SEVERNI JADRAN)

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POVZETEK

Avtorji obravnavajo topografski pregled za zaščito predlaganega rastišča morske trave pozejdonke med Izolo in Koprom. Gre za edini travnik te vrste na zahodni in severni istrski obali in obenem ostanek nekdanjih obsežnih travnikov v Tržaškem zalivu. Za ugotovitev favnistične in floristične pestrosti ter za ovrednotenje habitatnih tipov so uporabili metode podvodnega nedestruktivnega popisa.

Za obrežno območje med Žusterno in Moletom je značilna pestra množica habitatnih tipov, med katerimi je z vidika zaščite najpomembnejši travnik morske trave pozejdonke (Posidonia oceanica). *To je vrsta, ki je zaščitena tako v slovenskem kot tudi v evropskem merilu, njeni travniki pa so izjemno pomembni kot zavetišče ribjih mladic in kot ekološka niša za številne vrste bentoških alg in nevretenčarjev, ki na njej rastejo bodisi kot epibionti ali pa se skrivajo v koreninskih prepletih.*

Znatno večje območje sicer pokriva druga vrsta trave, kolenčasta cimodoceja (Cymodocea nodosa), *ki pa pozimi izgubi liste. Od zanimivejših habitatnih tipov je treba omeniti še terasaste kamnite sklade, ki jih najdemo na polovici poti med Moletom in Žusterno. Primerjava med posameznimi deli obravnavanega območja kaže, da je najmanj pestra favna bentoških nevretenčarjev na postaji ob kopališču Žusterna, medtem ko je na polovici poti do Moleta in ob samem Moletu favna neprimerno pestrejša. Podobno velja tudi za favno rib, ki je pestrejša ob Moletu. Pri tem poudarjamo, da bi z večjim številom vzorčevanj, predvsem pa z drugimi metodami, gotovo dopolnili ugotovljeni seznam flore in favne, medtem ko lahko za kartografski pregled habitatnih tipov trdimo, da gre za veren posnetek stanja na obravnavanem območju v času preiskav.*

Ključne besede: *Posidonia oceanica*, severni Jadran, topografski pregled, varstvo narave, nedestruktivne metode

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THE MEIOFAUNA OF TWO PROTECTED WETLANDS ON THE SLOVENE COAST: THE ŠKOCJAN INLET AND THE STRUNJAN LAGOON

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ABSTRACT

The paper presents ecological and meiofaunal comparisons between two extremely shallow intracoastal formations along the Slovene part of the Adriatic Sea, i.e. *the Škocjan Inlet in the Bay of Koper and the somewhat smaller Stjuža Lagoon near the salt-pans of Strunjan. The Inlet is a highly degraded, isolated and stagnant neritic environment, affected with temporary summer anoxias, caused by algal decompositions of huge* Ulva *aggregations. The Lagoon is an undisturbed sea grass community. Lower meiofaunal diversity and abundances were observed in the Škocjan Inlet, though less as expected, with some mixed "thiobios" symptoms in its highly sulforeducted surroundings.*

Key words: meiofauna, Škocjan Inlet, Strunjan Lagoon, protected wetlands

MEIOFAUNA DI DUE ZONE UNIDE PROTETTE DELLA COSTA SLOVENA: VAL STAGNON E LA LAGUNA DI STRUGNANO

SINTESI

L'articolo presenta un confronto ecologico e meiofaunistico tra due formazioni intracostali poco profonde: la Baia di San Canziano (Val Stagnon) nella baia di Capodistria e la più piccola laguna Stjuža vicino alle saline di Strugnano. La prima rappresenta un esempio di ambiente altamente degradato, isolato e stagnante neritico, affetto da temporanee anossie estive causate dalla decomposizione di ingenti aggregati dell'alga Ulva. *La laguna di Strugnano è invece una comunità indisturbata di fanerogame marine. Diversità e abbondanza meiofaunistiche sone risultate basse nella Baia di San Canziano, persino più basse del previsto, con alcuni sintomi misti "thiobios" nelle vicinanze altamente solforidotte.*

Parole chiave: meiofauna, Baia di San Canziano, laguna di Strugnano, zone umide protette

INTRODUCTION

The research carried out so far into the meiofauna of the Slovene sea has been focused mostly on the open waters of the Gulf of Trieste and much less on its shallow margins, the only exception being the extensive exploration of meiobenthos in the Strunjan Lagoon at the end of the 1970s (Vrišer, 1979, 1982). The shallow lagoonar part of Koper Bay, however, has till recently been totally unresearched. It was only the sampling carried out a couple of years ago in the Škocjan Inlet (Čermelj *et al.*, 2000) that enabled the origin of this paper, in which a comparison between the two very unique lagoonar environments, surrounded by land and officially protected, is presented. The contribution is not an integral, synchronously implemented study, but a comparative outline of this specific maritime environment at the level of meiobenthos. Here we were able to lean merely on the disposable, although for our particular purpose not always optimal ecological data. The Škocjan Inlet, which presently enjoys the status of a protected environment, will be in the future, after the planned deepening of its aquatory, certainly a subject of numerous investigations.

The study of lagoonar benthic associations and their appurtenant meiofauna, as an important part of these systems, presently deals with, judging from the literature, particularly the following four topical segments.

In the foreground are largely investigations of bioproductional characteristics, faunistic structure (taxonomy) and diversity ecology of their associations. Since the complexity of the three stated spheres inseparably interact between each other, the mentioned research aspects can be usually found in joint, more complex publications, such as Coull (1969, 1970); den Hartog (1971); Sikora & Sikora (1982); Witte & Zijlstra (1984); Fleeger *et al.* (1984); Armonies (1988); Bin Sun *et al.* (1993); *etc.* The fourth and very special sphere of lagoonar studies constitute the research on specific putrescent and to the high concentrations of sulphuretted hydrogen adapted meiobenthic associations of the extreme maritime environments, the so-called thiobioses (Reise & Ax, 1979, 1980; Powell *et al.*, 1980, 1983; Meyers *et al.*, 1988; Wetzel *et al.*, 1995).

The samplings in the Škocjan Inlet and its stagnant tributaries, which are heavily marked with decaying substrate, were carried out also in order to ascertain the possible "thiobiosity" of this environment.

ECOLOGICAL CONDITIONS

Due to the exceptional specificity of the study area, some more space is dedicated to its ecological outline than actually deserved by this preliminary meiobenthic delineation in view of the extent of the achieved results.

Position, depth configuration and hydrological regime of the Inlet and the Lagoon

The two systems, the one at Škocjan as well as the one at Strunjan, are not entirely natural formations but the result of various human activities carried out in the last few centuries in this shallow marine environment, enabled by the estuaries of the Rižana river in Koper Bay and of the Strunjan stream and its discharge area in Strunjan Bay.

The Škocjan Inlet originated with the linking of the former island of Koper with land through the complex of salt fields, and was finally cut off from the sea by the new Port of Koper, due to which it now communicates with the sea only through the narrow man-made canal. The extensive filling up of the Inlet in the last thirty years has made this once entirely marine environment extremely shallow (the depth of its central part does not exceed 30 cm), virtually cut it in half as far as its surface area is concerned and thus made life in it unbearable. Its only freshwater tributaries, the canals of the Rižana river and the Badaševica stream (Fig. 1), are scarce with water, while the smaller and presently more or less freshwater mere (with its own small spring) is only a part of the Inlet, cut off from the main body by the railway embankment. With its spillway past the Inlet, the Badaševica stream has been diverted directly into Koper Bay.

The Strunjan Lagoon (Fig. 2) is for some half a century abandoned fish farm of the Venetian type. It is an artificial formation, with no direct freshwater inflow, originating from the time when the Strunjan salt-pan complex was formed. It is made up of the smaller discharge lagoon and of the larger main Stjuža Lagoon of the silted former fish-farming pond. The latter is up to half a meter deep and through the mouth of the discharge lagoon (and a series of smaller spillways between the two lagoons) hydrologically (intertidally) fairly effectively and much more directly linked with the sea than the Škocjan Inlet.

Temperature, salinity, and oxygen

Thermal conditions in both lagoons are, owing to their shallowness, very severe and seasonally change from one extreme to the other: in the winter between 5° and 10°C (they periodically freeze over), and between 24° and 27°C during the summer, while in other seasons they adapt to the atmospheric temperatures.

Salinity and oxygen content of the Škocjan Inlet's water body oscillate a great deal both temporally and spatially: from periodically almost freshwater conditions in the rainy seasons, via brackish level of salinity to quite high salinities in warmer periods (hypo – hypersaline environment). The salinity and oxygen measurements in the Inlet also showed some extreme spatial

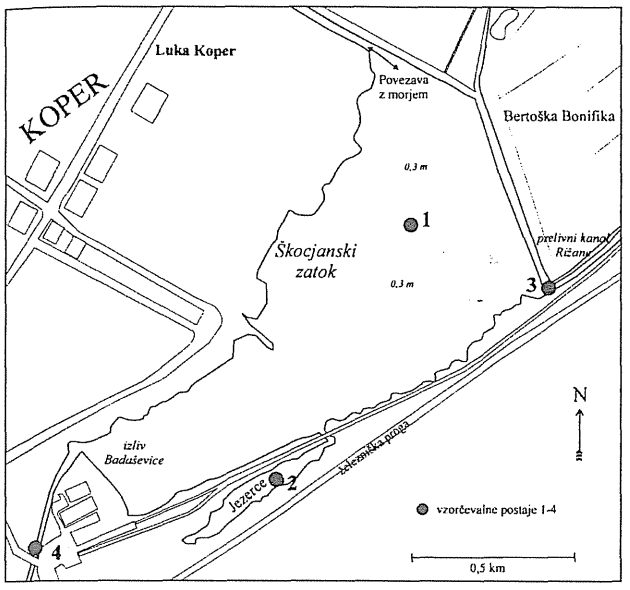

Fig. 1: Study area with sampling stations in Škocjan Inlet.
Sl. 1: Raziskovano območje z razporeditvijo vzorčevalnih postaj v Škocjanskem zatoku.

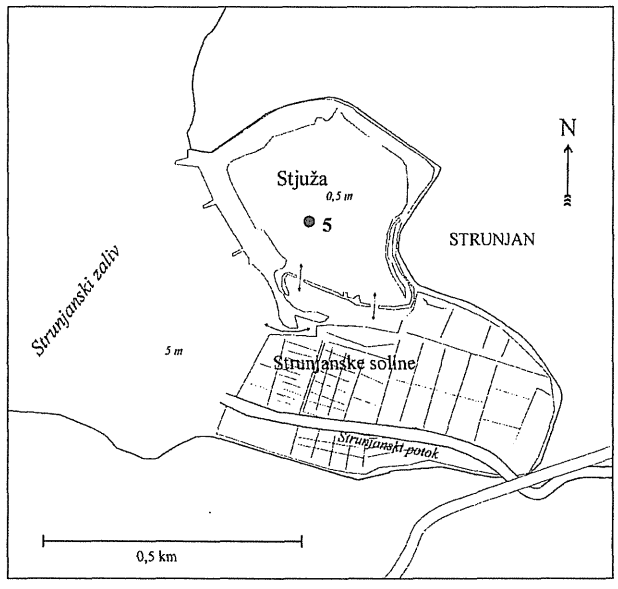

Fig. 2: Study area with sampling station in the Strunjan Lagoon.
Sl. 2: Raziskovano območje z vzorčevalno postajo v Strunjanski laguni.

changes due to the mixing of strong tidal flows: utterly comparable with the outer condition (in the Bay) along the inner mouth of the tidal canal, and severe along the mouth of the spillway canal of the Rižana river and the Badaševica stream (high salinities, around 40 psu, and consequently critically low, with hypoxic oxygen values – below 30 ppm).

Similar hypoxic and occasionally even anoxic conditions of the water oxygen often occur in late summer in the Inlet itself, although exclusively due to the massive decaying of the huge agglomerations of sea lettuce accumulated at the time of low water levels, saturated nitrites and high temperatures. For the time being, however, we have no detailed accompanying ecological data on the physical-chemical changes in this process, which may at times bring the system into the state of biotic collapse. The only permanent freshwater locality of the Inlet can be found in the already mentioned mere, where seawater can be detected only at its bottom.

Salinity, oxygen content and thermal conditions in the Strunjan Lagoon are owing to the more direct as well as ample water exchange generally completely comparable with those of Strunjan Bay, in spite of ever present intertidally turbid oscillations in the Lagoon.

Plankton

Phytoplankton density in the Inlet and in the Lagoon is high, in fact higher than in open waters, while its species diversity is much lower. Phytoplankton biomass in terms of chlorophyll *a* concentration in the Škocjan Inlet generally surpasses the averages of the Gulf of Trieste (around 1.0 µg/l). Chlorophyll *a* concentrations oscillate a great deal both temporally and spatially, from the low 1.8 µg/l in winter to the high 220 µg/l in spring (Čermelj *et al.*, 2000). The measurements made in the Strunjan Lagoon have shown comparable, although slightly lower values. In the species-poor phytoplankton association, microflagellates are predominant (70 – 90%) (Čermelj *et al.*, 2000).

The zooplankton fauna, too, is poorer in view of its species than in open waters, with predominant naupli larvae and harpacticoid copepods of the benthic-semipelagic type. No great differences can be detected between the Inlet and the Lagoon.

Substrate

Substrate of the major part of the Inlet and the Lagoon is grey-coloured compact-fine argillaceous silt with a slight admixture of sand, with a thin (0.5 – 1 cm) yellowish brown layer of flocculent organic detritus. This is the main natural habitat of the researched, predominantly burrowing meiofauna, which with a branched out capillary system of oxygenated burrows also inhabits up to 5 cm deeper layers of otherwise anaerobic although unreduced unputrescent substrate.

The sediment in the mouth of the Badaševica stream and in the discharge canal of the Rižana river, however, is completely without aerobic surface layer, highly putrescent and thus badly degraded, of black coloured, with high decomposing organic detritus content. Sulfide

hydrogen remains permanently dissolved in pore water of this substrate in high measured concentrations (0.5-2.5 mmol/l).

Macrophytobenthos

Macrophytobenthos of the Škocjan Inlet is, owing to its exceptional shallowness, almost entirely limited to the free floating benthopleustophytous and acropleustophytous species, such as *Ulva rigida* (sea lettuce) and, to a smaller extent, *Gigartina acicularis* and *Halopitys incurvus*. As a result of the increased evaporation, low water level and greater amount of nitrites during the summer, water lettuce spreads in the Inlet to such extent that it fills up the entire water volume and due to it and especially owing to its decaying disables the existence of the *Cymodocea* sea meadow, which once commanded at that time much deeper Inlet.

The Strunjan Lagoon is overgrown with a normally developed sea meadow consisting predominantly of the species *Cymodocea nodosa*, and *Zostera noltii* on its margins. Species diversity is usual for this phytoassociation, for apart from the two above mentioned species, at least another 7 species are present there.

Macrofauna

Macrofauna of the Strunjan Lagoon consists of a very diverse association of characteristic species closely associated with the environment of seagrasses: numerous mollusc (bivalves, gastropods), benthic crustaceans (mysids, amphipods, decapods, isopods), echinoderms (brittlestars, starfishes), and at least 20 species of polychaets.

In the ecologically degraded Škocjan Inlet, no comparable macrofauna association was noted, with the exception of few polychaets and bivalves.

MATERIAL AND METHODS

The first sampling was carried out on October 26th 1999 at four localities of the Škocjan Inlet, *i.e.* in its centre (Station 1) and on its margins (Stations 2 – the mere on the other side of the railway embankment, 3 – the Rižana river channel, 4 – the bed of the Badaševica stream) (Fig. 1), and at a single locality in the Strunjan Lagoon (Station 5) (Fig. 2). The second sampling was carried out on March 8th 2000 in the central parts of the Inlet and the Lagoon only.

We took the substrate samples manually with corer and extracted the meiofauna from the surface area of 10 cm^2 and the depth of 5 cm with the sieving-decantation technique in 2 fractions (50 - 125 μm, 125 μm - 1 mm) of Wieser (1960) and conserved it in 4% formalin with seawater.

The basic physical and chemical characteristics of the water column (temperature, salinity, dissolved oxygen, chlorophyll *a*) were determined with CTD fine-scale profiler (University of Western Australia, Centre for water research) while at somewhat shallower localities classical methods were partially applied as well. Numerous other analysis techniques for the ecological measurement of the substrate are presented in greater detail in the ecological study made by Čermelj *et al.* (2000).

RESULTS

Qualitative survey of the meiofauna of the Strunjan Lagoon, Škocjan Inlet and their affluents

The first preliminary qualitative analysis (presence of major taxonomic groups and their rough quantitative assessment) of 6 meiofauna samples was carried out in mid-October 1999. The survey showed two groups of samples (Tab. 1).

Tab. 1: Meiofauna of the Strunjan Lagoon and the Škocjan Inlet, together with its affluents, October 1999. Taxa are ranking according to decreasing abundance. Stations: 1 - Škocjan Inlet's centre, 2 – mere, 3 - Rižana river's discharge canal, 4 - Badaševica stream, and 5 - Strunjan Lagoon (reference sample). Legend: RR-very rare, R-rare, C-common, CC-very common, and D-dominant.

Tab. 1: Meiofavna Strunjanske lagune in Škocjanskega zatoka ter njegovih pritokov, oktober 1999. Taksoni so urejeni po standardnem zaporedju običajne pogostosti. Postaje: 1 – center zatoka, 2 – jezerce, 3 – prelivni kanal Rižane, 4 - Badaševica in 5 Strunjanska laguna (referenčni vzorec). Legenda: RR-zelo redka, R-redka, C-običajna, CC-zelo običajna in D-dominantna.

	Škocjan Inlet				Strunjan
	1	2	3	4	5
Nematoda	CC	C	RR	R	D
Harpacticoida	R		R		CC
Polychaeta	CC	RR		RR	CC
Turbellaria	C	RR	RR	R	C
Gastropoda	RR				C
Bivalvia					R
Kinorhyncha					RR
Acarina					RR
Hydroidea					RR
Ostracoda	D	RR	D	R	
Tanaidacea	R				
Isopoda	RR		R		
Amphipoda	R		R		R

The meiofauna of the three marginal water bodies of the Škocjan Inlet (the Badaševica stream, the mere, and the Rižana river discharge canal) with distinct signs of ecologically degraded environment (large quantities of decaying black detritus in the sediment) was taxonomically, and particularly quantitatively, very poor in comparison with the fauna of the Škocjan Inlet and the Strunjan Lagoon. The samples taken in the Inlet and Lagoon showed a higher diversity and abundance of individuals.

A comparison between the Inlet and the Lagoon, however, showed somewhat lower abundance in the meiofauna of the Škocjan Inlet, particularly in respect of the Nematoda and Harpacticoida groups. The meiofauna of the Strunjan Lagoon served as a reference for a less affected environment.

Quantitative survey of the meiofauna of the Strunjan Lagoon and the Škocjan Inlet

The analysis of the meiofauna's samples taken on March 8th 2000 at two stations in the Škocjan Inlet and comparatively in the Strunjan Lagoon, showed a great difference between the two aquatories than the preliminary qualitative survey carried out in 1999 (Tab. 2).

Tab. 2: Meiofaunal structure and abundance (No. ind. /10 cm^2) of the Škocjan Inlet and the Strunjan Lagoon, March 2000. Taxa are ranking according to abundances.
Tab. 2: Struktura in abundanca (št. os./10 cm^2) meiofavne Škocjanskega zatoka in Strunjanske lagune, marec 2000. Taksoni so urejeni po zaporedju abundanc.

	Strunjan Lagoon (St. 5)				Škocjan Inlet (St. 1)			
taxa	a	b	c	mean	a	b	c	mean
Nematoda	541	692	837	**690**	403	307	343	**351**
Harpacti-coida	139	289	341	**256**	38	36	69	**48**
Polychaeta	68	201	93	**121**	75	12	21	**36**
Turbellaria	27	28	38	**31**	8	8	8	**8**
Gastropoda	-	1	-	**0.3**	-	-	1	**0.3**
Bivalvia	1	-	-	**0.3**	-	-	1	**0.3**
Kinorhyncha	-	2	4	**2**	1	-	-	**0.3**
Acarina	1	-	-	**0.3**	-	-	1	**0.3**
Hydroidea	75	2	-	**26**	-	-	-	-
Ostracoda	6	20	22	**16**	73	87	130	**97**
Amphipoda	3	-	1	**1.3**	-	-	1	**0.3**

In terms of diversity, and particularly as far as its quantity is concerned, the Škocjan Inlet's meiobenthos is much poorer than that in the Strunjan Lagoon. In the majority of the faunistic groups, the quantitative differences are also great. In otherwise numerous nematods (Nematoda), present in both environments, the abundances in the Škocjan Inlet were by half as low than in the referential lagoonar environment, in Turbellaria four times lower, in harpacticoids (Harpacticoida) five times lower, and in polychaets (Polychaeta) even seven times lower than at the referential station.

The only exception were ostracods (Ostracoda), which with their no less than six times greater abundance than the prevalent meiobenthic group of the Škocjan Inlet mark this specific, although undoubtedly degraded association.

DISCUSSION

In comparison with the Strunjan Lagoon, the assessed smaller diversity of the Škocjan Inlet's meiofauna is not particularly explicit and is in fact based merely on the first observations. During the first (preliminary) survey of the Inlet, we did not manage to register no less than four groups: bivalves (Bivalvia), kinorhynchs (Kinorhyncha), acarins (Acarina) and colonies of hydroid polyps, which all happen to be common in the Strunjan Lagoon. Particularly symptomatic is the almost total absence of molluscs (bivalves and gastropods), which were hardly registered yet again during the second and much more thorough survey of the Škocjan Inlet. A further supplement to the assessment about a poorer diversity of the Inlet's meiofauna is represented by harpacticoid copepods (Harpacticoida), where representatives of only three genera were prevalent: *Amphiascus, Bulbamphiascus* and *Tisbe*. Especially in the last two, some distinct indicators of eutrophic as well as organically polluted environments can be found (Marcotte & Coull, 1974; Vrišer, 1986).

Much more distinct between the compared associations of both lagoonar environments are the quantitative differences, where the spans of higher abundances in the individuals of the Strunjan Lagoon are even several times greater in some of the groups. So far, much has been written about the meiofauna of the Strunjan Lagoon (Vrišer, 1979, 1982). At this point let us underline that we are dealing with meiobenthos, closely associated on sea grasses, in which some stenovalent species are missing in many groups due to the severe oscillation of ecological factors (particularly temperatures and salinity). But then again it is distinguished for its bioproductivity, which is higher than in the open sea, which is reflected in greater, especially summer abundances of its dominants. Otherwise it is more or less still comparable with the ordinary meiobenthos of the coastal sea meadows.

However, our assessment of the species diversity in meiobenthic associations in both environments can be unfortunately merely preliminary without a detailed study of the species diversity and a greater spatial covering of the sampling stations.

There is no doubt that all the stated faunistic differences between the two compared environments result from the great ecological differences between them, particularly from the absence of the ruined sea meadow of the Škocjan Inlet and from the anoxic collapses in the summer. It is our impression that the great quantities of decomposing detritus of sea lettuce hypoxically (and in a later phase anoxically) cover and pollute the surface of the bottom to such extent that the meiofauna can survive, in the short run, only inside this already thinner (max. 1 cm thick) but still aerobic layer and in up to 5 cm deeper capillary network of burrows of the meiofauna's burrowing component. The latter is indeed capable of surviving (for up to few weeks) in the hypoanoxic conditions of this kind as well, to which macrobenthos succumbs in a very short time (as confirmed by numerous foreign and domestic anoxia researchers, *e.g.* Josefson & Widbom, 1988; Austin & Widbom, 1991; Vrišer & Malačič, 1992; Vrišer, 1995; Moodley *et al.*, 1997), *i.e.* in the ecological conditions, when after a week or two the macrofauna has long been destroyed. We presume that early in the autumn life conditions improve in the Inlet due to heavy rains and winds (when decomposing aggregations of algae are washed away), as shown by our October and March samplings. The colder half of the year most probably presents a more favourable ecological period for the fauna of the Škocjan Inlet.

The mentioned survey of processes is probably not utterly uniform even in the period of the most intense summer putrification, but is most likely mosaic: it is a mixture of hydrodinamically more stagnant (ecologically severed) and intertidally more intense (ecologically more favourable) localities with less polluted aggregations. For this purpose, a network of stations would be necessary.

On the other hand it has been noted that the registered faunistic differences between the compared Škocjan Inlet and the Strunjan Lagoon are certainly smaller than the ecological differences, or smaller than expected in view of the latter. All this yet again confirms the meiofauna's well-known ecological resistance as well as its flexibility and "belated" response to the environment's unfavourable ecological extremes.

The Škocjan Inlet's benthic conditions could be perhaps explained with the following working hypothesis. It is possible that the decisive role in the incurred meiofaunal differences in both compared environments is played by the very substrate endofraction of macrobenthos (over 1 mm large organisms living on the bottom, *i.e.* bivalves, nemerteans, polychaets, oligochaets), which in the critical summer hypoxia cannot survive in the long run and is therefore hard to be found any longer in the Škocjan Inlet. This directly means its loss or absence as well as a reduced presence of "temporary" meiofauna, *i.e.* juvenile stadia of the future macrofauna. At the same time this indirectly means – due to the consequential loss of macrobenthic capillary network of oxygenated burrows as oxygen lacunas within the top 5cm – a fatal reduction of the disposable life niches for the remaining "permanent" meiofauna, which is reflected not only in the diversity of species but also in their abundance. In the meiofaunistic literature we have not found an ecosystem that would be ecologically fully comparable to the Škocjan Inlet. Some authors (*e.g.* Coull, 1969; Sikora & Sikora, 1982), on the other hand, are breaking down the biological processes of the surface layer in the substrate of the shallow lagoonar environments also in the direction of the above mentioned hypothesis.

The other objective of our research was to find an answer to the question, whether there exists, in the Škocjan Inlet and particularly on its margins, a specific and to sulphuretted hydrogen adapted meiobenthic association, the so-called "thiobioses". Certain sources have placed this (in the opinion of some researchers disputable) association in sulfide dependent chemocline which presumably have an ecologic requirement for sulfide (Powell *et al.*, 1983). Thiobios communities no longer needs the necessary oxygen for its survival (Reise & Ax, 1980; Meyers *et al.*, 1988), in contrast to the normal meiobenthos, therefore, which is (at least in a long run, *e.g.* a few weeks) certainly still dependant on surface oxygen, also in deeper burrows within anaerobic substrate, even though below a depth of 10 cm.

Of the four investigated localities we can immediately exclude the Inlet itself, which does not fully meet the searched conditions (for the major part of the year its surface sediment is oxygenated), and the brackish mere protected from the decaying aggregations of the organic detritus by the railway embankment. The remaining two localities, *i.e.* the discharge canals of the Rižana river and the Badaševica stream, are, on the other hand, heavily stagnant and at the bottom burdened with the earlier on defined characteristics of decaying nature and, according to our measurements, with confirmed high sulphide concentrations. This environment is ecologically thus fairly congruent with "thiobiosity", while our faunistic data show somewhat mixed picture and only partially correspond to the previously mentioned specialist sources that classify such associations. Similarity with them is shown mainly in the exceptionally sparse harpacticoid copepods (Harpacticoida) and polychaets (Polychaeta) of our samples – in such environments these groups are normally rare – but not in ostracods (Ostracoda), which are even predominant in the discharge canal of the Rižana river and the second most common group in the Škocjan Inlet. The very multitude of ostracods in our samples of this environment is a faunistic peculiarity, discordant with thiobiotic associations, and for the time being difficult to explain. The groups Turbellaria and Kinorhyncha, characteristic of

decaying environments, were also missing in the two canals.

At the moment, the present survey of these margins of the Škocjan Inlet does not enable us a final judgement, and an answer could only be given upon a more extensive research.

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MEIOFAVNA DVEH ZAVAROVANIH MOKRIŠČ SLOVENSKE OBALE: ŠKOCJANSKEGA ZATOKA IN STRUNJANSKE LAGUNE

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POVZETEK

Primerjali smo meiofavno dveh plitvih, zaprtih priobalnih lagun, obe s statusom naravovarstveno zaščitenega območja. Škocjanski zatok, ki je danes skoraj že zasut preostanek nekdanjega estuarija reke Rižane, je primer skrajno degradiranega in hidrodinamično stagnantnega neritičnega okolja, močno obremenjenega z občasnimi poletnimi anoksijami. Morski travnik tu ni več ohranjen. Povzročajo jih razpadajoče agregacije morske solate Ulva lactuca. *Ugotovili smo, da so združbe v Škocjanskem zatoku vrstno in količinsko siromašnejše od združb v Strunjanski laguni. Ugotovljene favnistične razlike pa so bile vendarle manjše od pričakovanih in občutno manjše od ekoloških. Meiofavna dveh stranskih pritokov zatoka, močno zaznamovanih z gnijočim sedimentom, kaže nekaj delnih znakov specifičnih, na sulfidno okolje prilagojenih tiobioznih združb.*

Ključne besede: meiofavna, Škocjanski zatok, Strunjanska laguna, zavarovana mokrišča

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MANAGEMENT AND CONSERVATION OF WETLANDS AND WATER RESOURCES IN SLOVENIA WITH REGARD TO THE NEW EUROPEAN WATER LEGISLATION

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ABSTRACT

The European Union Water Framework Directive (WFD) is considered as a major contribution to the European environmental legislation. It also provides important implications for the implementation of the EU directives for nature conservation, namely the "Birds" and the "Habitats" Directives which forms a legislative framework for the network of protected areas, known as Natura 2000. The consequences for nature and especially wetland conservation in the framework of the Natura 2000 network after adoption of the WFD are analysed. A short description of water management and wetland conservation planning and management is presented, together with a brief presentation of the extent of wetland types in Slovenia.

Key words: water management, nature conservation, wetlands, European Union, Water Framework Directive, Birds Directive, Habitats Directive, Slovenia

GESTIONE E TUTELA DELLE ZONE UMIDE E DELLE RISORSE IDRICHE IN SLOVENIA ALLA LUCE DELLA NUOVA LEGISLAZIONE EUROPEA

SINTESI

La direttiva sul patrimonio idrico dell'Unione Europea "Water Framework Directive" (WFD) viene considerata il contributo più importante alla legislazione ambientale europea. Il documento fornisce importanti implicazioni per l'adempimento delle direttive EU per la tutela della natura, in particolare degli uccelli e degli habitat. Le direttive formano una cornice legislativa per la rete delle aree protette, conosciuta come Natura 2000. Nell'articolo vengono analizzate le conseguenze per la tutela della natura ed in particolare delle zone umide nella cornice della rete Natura 2000 dopo l'adozione della WFD. Gli autori presentano inoltre una breve descrizione della gestione del patrimonio idrico e dei progetti di conservazione e gestione delle zone umide, con una concisa presentazione dell'estensione dei tipi di zone umide in Slovenia.

Parole chiave: gestione del patrimonio idrico, tutela della natura, zone umide, Unione Europea, direttiva sul patrimonio idrico, direttiva sugli uccelli, direttiva sugli habitat, Slovenia

INTRODUCTION

Water Management in Slovenia

Slovenia is rich in water resources, with 80% of them within the Danubian and 20% within the Adriatic watersheds. The country borders Italy, Austria, Hungary and Croatia and consequently there are numerous trans–border river crossings. All water management issues (including trans – border) are under the domain of the Ministry for the Environment, Spatial Planning and Energy.

The changes in water management policy that have occurred since 1981 (when the previous Water Act has been adopted) resulted in the recently adopted Water Act (2002). These can be divided into two major groups:

- changes due to updating of the currency values (during the high rate of inflation period) and
- changes due to the new political system (changes in institutional and other water management system).

The water management area, with its broad effect on several sectors and individuals, intensively interacts with other legislations. One of these is the Environmental Protection Act, adopted in 1993. It was supposed to be the general framework for all later environmental and natural resource legislations. It is focused especially on the improvement of water, soil and air quality. The result of this is the fact that the monitoring of emissions, taxation for wastewater and air pollution taxation are already well under way.

The majority of water management related activities are under competence of the Ministry of the Environment, Spatial Planning and Energy (MOP). There are also seven units working within the MOP. Within the Environmental Agency of the Republic of Slovenia the Water Management sector performs most water management activities. It has eight regional offices close to the river basin scale, which deal almost exclusively with these issues. At the state level eight water management companies and one company for torrent areas management perform public services – maintain watercourses and manage the state owned water management infrastructure.

The MOP along with public services deal predominantly with the quantity of water resources, flood and erosion control, and the quality of the water environment protection and wastewater emission taxations, as well as monitoring responsibilities.

The responsibilities that are under the jurisdiction of local communities, according to the Water and the Environmental Protection Act are:

- the management and maintenance of drinking water supply facilities,
- the management and maintenance of wastewater collection and treatment facilities,
- waste collection, treatment and disposal.

Local communities may join to form interest-based associations in cases where systems for providing the services mentioned above would involve several of them. The provision of public services is controlled by the local community, the associations of users and the state inspectorate. Public service providers also have to perform the prescribed self-monitoring.

The most urgent and critical issue to be solved is water management planning. The new Water Act provides legal basis specifically for this purpose. Recent work in water management is catchment oriented. Catchment management plans have already been prepared for some catchments, *i.e.* for the Kokra, Dragonja, Drava, Idrijca, Kolpa, Krka, Badaševica and Rižana rivers *etc.* These plans are an important step towards gaining experience how to prepare river basin characteristics and river basin management plans, and especially how to involve the public in this process.

These documents were prepared on the basis of Slovenia's international obligations as part of the pre-accession activities to the European Union and on the basis of the EC Water Framework Directive.

Wetland Conservation in Slovenia

The Ministry of Environment, Physical Planning and Energy is responsible for nature conservation in Slovenia. Its administrative and technical advisory body is the Institute of the Republic of Slovenia for Protection of Nature. The seven regional units for protection of nature act as technical supervisory bodies at the local level.

The Environmental Protection Act passed in 1993 represents the regulatory system for both environmental protection and nature conservation. A Nature Conservation Act was adopted in 1999, which, among other provisions, established a legal basis for integration of nature conservation principles into other sectors.

National Biodiversity Strategy (ARSO, 2001) is considered as part of the obligations of the Republic of Slovenia to the implementation of the Convention of the Biological Diversity (CBD), National Programme for Environment and Nature Conservation Act and it is under the auspices of the Slovenian Ministry of Environment, Physical Planning and Energy. Preparation of the National Wetland Conservation Strategy is understood as an appropriate tool for effective wetland conservation in Slovenia.

INVENTORY OF WETLANDS AND WETLAND CONSERVATION IN SLOVENIA

The inventory of wetlands and rivers in Slovenia was prepared in 2001 (Sovinc, 2001). The database contains information on 3525 wetland sites, which are distributed over 31 catchment areas.

The total area of recorded wetlands, including flood zones is 98,758.93 ha (or 4.87% of the territory of Slovenia). In Slovenia, there are 19 (of 40) types of wetland

according to the classification of wetlands in the Ramsar Convention (Fig. 1). The most common wetland type in Slovenia are "ponds" which include characteristic Karst waterholes; there are 1517 such wetlands, spread over 134.38 ha. "Excavations" (gravel/brick/clay pits; borrow pits, mining pools, *etc.)* are recorded in 584 sites with a total area of 363.438 ha. Then follows "Aquaculture (*e.g.* fish/shrimp) ponds" (312 sites, total 225.308 ha) "Seasonally flooded agricultural land" with 304 sites on 18,079.597 ha, which is also the largest extent of an individual type of wetland in Slovenia. Only in fifth place by number of sites is the first type of "natural" wetland (the first four most frequent types are all "man-made wetlands"): there are 279 recorded wetlands of "Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season" which cover 168.692 ha.

NEW APPROACH IN WATER MANAGEMENT

The Water Framework Directive (WFD), adopted by the European Community on 23 October 2000, is considered as a major contribution to the European environmental legislation. It is especially important for all types of aquatic and wetland ecosystems, as this is the first time that the protection of these ecosystems is dealt with by one legal instrument at the European level. In addition, WFD brings important implications for the implementation of the Natura 2000 network, based on the implementation of the EU Birds and Habitats Directives.

EU Directives constitute the basic legislation for EU member states. Once Slovenia becomes a member of the European Union (2004?), these Directives will become obligatory and will be considered as the basis legislative tool at the national level.

WFD provides an obligation, but also an opportunity for EU member states to adopt a more global approach to conservation by developing a programme of measures at the river basin level. Political or administrative stages must be overlooked.

Member states must take the following steps to meet the requirements of WFD:

- to assign the individual river basins to a river basin district (RBD; going across the national borders if the river crosses them),

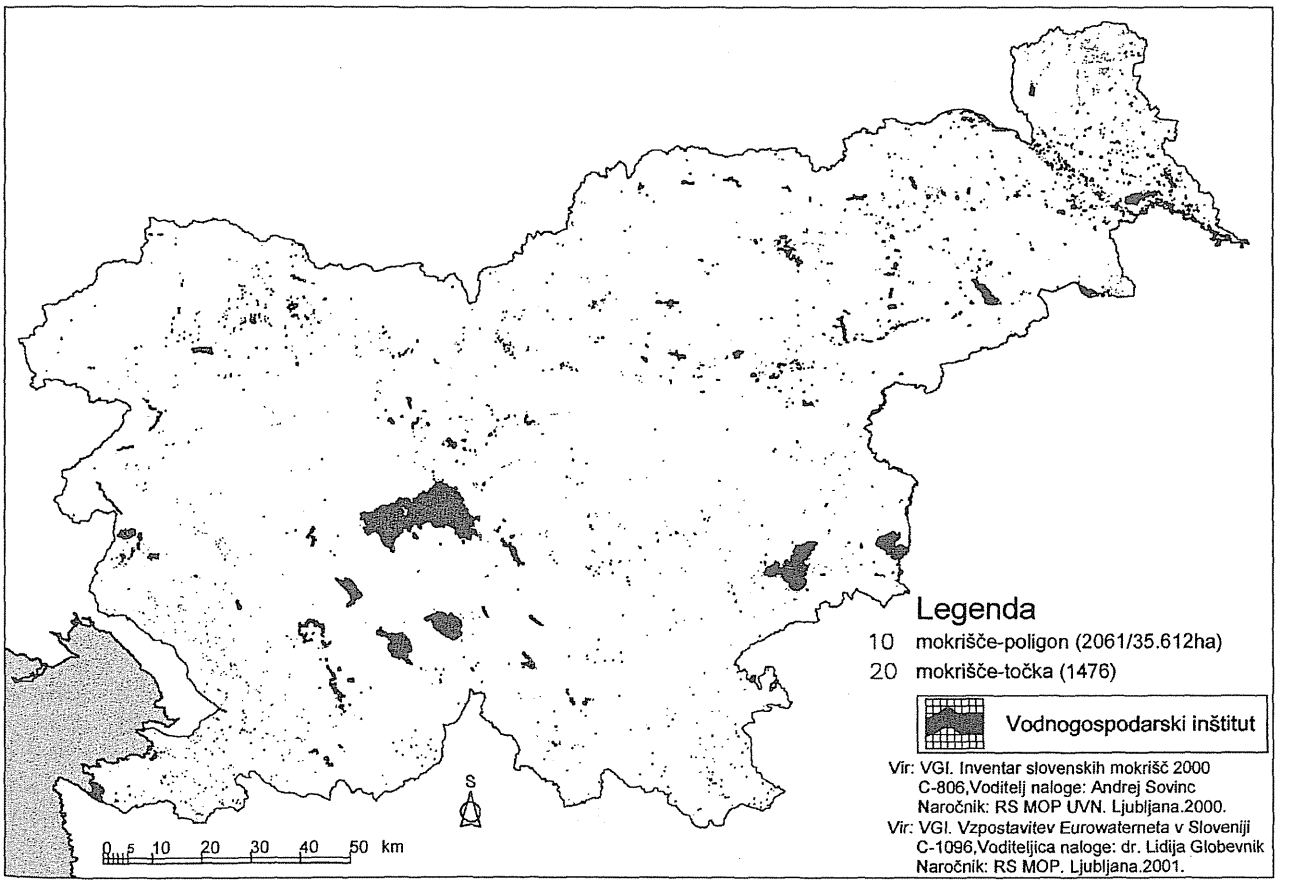

Fig. 1: Wetlands of Slovenia (Water Management Institute, 2001).
Sl. 1: Slovenska mokrišča (Vodnogospodarski inštitut, 2001).

- to identify the competent authority responsible for the application and implementation of WFD,
- to collect information and categorise different water bodies within each RBD,
- to undertake an analysis of the human impact on water bodies,
- to prepare a programme of measures, taking into account the provisions of all other EU Directives (11).

Integrated approach to the water management issues is yet to be established in Slovenia. It is important to emphasise that the new Water Act provides the legal basis for implementation of the Water Framework Directive.

One of the most important tasks regarding the Water Framework Directive and the tool for implementation of the Natura 2000 network (see below) is the preparation of a management plan. This has to be produced for each river basin district and it must cover the entire area. The division into sub basin survey areas is also allowed and it is a matter for national authorities that share the control over a river basin. In accordance with Water Framework Directive, Article 3 (Directive 2000/60/EC) all the river basins have to be assigned to an individual river basin district. It is also allowed that smaller river basins may be combined with larger river basins or joined with neighbouring small basins to form an individual river basin district where appropriate. River basins exceeding national boundaries have to be assigned to an international river basin district (Fig. 2).

In Slovenia, the Danube and Adriatic river basin districts have been included in the new Water Act and declared part of the international river basin district.

WATER MANAGEMENT AND NATURE CONSERVATION

The EU's policy on nature conservation is made of two Directives: Council Directive 79/409/EEC (the Birds Directive) and Directive 92/43/EEC (the Habitats Directive).

Together, these Directives form a legislative framework for the protection of Europe's plants, animals and habitats. The creation of the ecological network of protected areas - known as Natura 2000 - is emerging from:

- Special Protection Areas (SPAs) to conserve 182 bird species/sub-species (listed in Annex I to the Birds Directive) and migratory birds, and
- Special Areas of Conservation (SACs) to conserve more than 250 habitat types, 200 animal and more than 430 plant species (listed in Annexes to the Habitats Directive).

The purpose of Natura 2000 is to maintain or restore the habitats and species at a favourable conservation status in their natural range.

WHAT ARE THE CONSEQUENCES FOR NATURE, AND ESPECIALLY WETLAND CONSERVATION, AND THE NATURA 2000 NETWORK AFTER ADOPTION OF THE WFD?

- There is now a clear legal link established between the EU protected area legislation (Natura 2000) and protection of river basins. The requirements of the birds and the habitats directives have to be taken into consideration when planning and implementing actions to improve water quality.
- The diction of *"good water status"* in the WFD provides opportunity for wetland restoration. If a restored wetland will contribute towards the enhancement of the water status, this should be indicated in the programme of actions at the river basin level.
- WFD established the link between the waters and their ecological state in terms of biological diversity, structure and function and special attention is put on the fulfilment of the needs of the wetlands to maintain their character.
- The list/inventory of Natura 2000 sites (and other protected areas) have to be prepared and regularly updated as required in the Article 6 of the WFD. In other words, maintaining of the ecological character of Natura 2000 sites has to be stated as a clear aim when devising actions at the river basin level. In practice, this means that the management plans for Natura 2000 sites should form an integral part of the catchment planning process.
- All Natura 2000 sites have to be mapped out (this is also true for all other water bodies!) and these maps should be incorporated into management plans.
- WFD also provides an opportunity to ensure effective monitoring of Natura 2000 locations, including other wetland and water sites. WFD requires that "A good water status" is to be achieved in all European community waters: inland surface waters, transitional waters, coastal waters and groundwater). In the case of surface waters, this state should be achieved through measuring of "ecological status" (according to the quality of water ecosystems) and of *"chemical status"* (by the levels of specific pollutants present) for ground waters, the monitoring system is based both on core parameters of water chemistry and on the *"quantitative status"* of groundwater.
- As part of the monitoring requirements under the WFD, the impacts of pressures have to be assessed as part of the human impact analyses.
- The requirement of the river basin management plan is to undertake an economic analysis of water use. Although this statement might appear tricky in some cases (Article 4, No 4.a), Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales set out in the paragraph for at least the following reason: "completing the improvements within the time

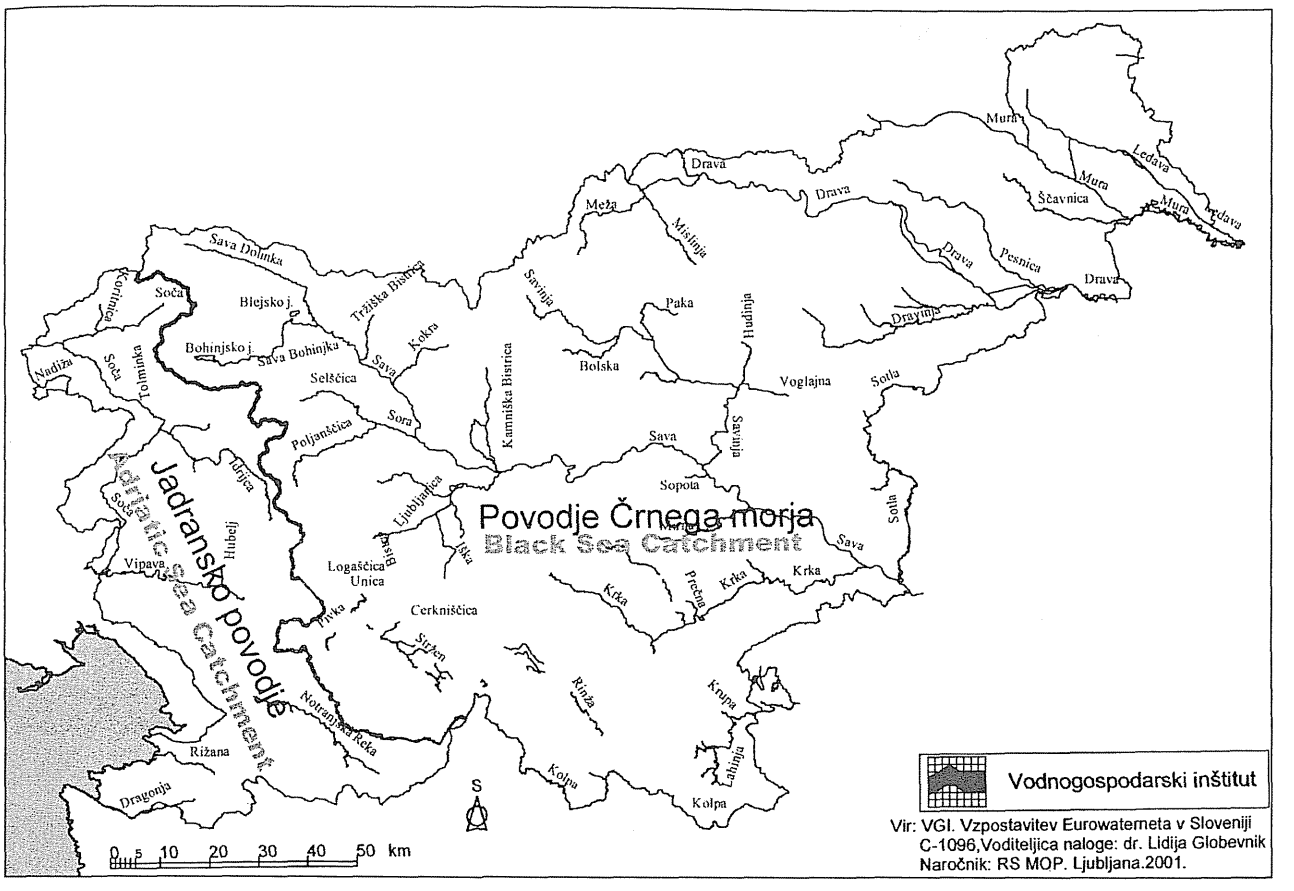

Fig. 2: Transboundary character of rivers in Slovenia (Water Management Institute, 2001).
Sl. 2: Čezmejni značaj slovenskih rek (Vodnogospodarski inštitut, 2001).

scale would be disproportionately expensive". It is however hoped that economic arguments for restoring wetlands (water purification, natural retention areas, recreation...) will be considered as prevailing when assessing cost effective solutions to obtain good water status.

CONCLUSIONS

New approach to water and wetland conservation in Slovenia is based on the implementation of the European Union Directives: the Water Framework Directive, the Birds Directive and the Habitats Directive. Water catchment approach is used to respond to the questions of planning and management of water and wetland resources. Efforts are made to adopt national legislation and preparatory steps to correspond to the above EU legislation, which will also become obligatory for Slovenia, once it joins the European Union.

UPRAVLJANJE IN VARSTVO MOKRIŠČ TER VODNIH VIROV V SLOVENIJI V OKVIRU NOVE EVROPSKE ZAKONODAJE

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POVZETEK

Smernice Evropske zveze o skupni politiki do voda (Water Framework Directive) so pomemben prispevek k evropski okoljski zakonodaji. Posamezna določila smernic vplivajo tudi na uresničevanje naravovarstvenih smernic Evropske zveze, t.j. "ptičjih" in "habitatnih" smernic. Te so pravni okvir za razglasitev omrežja zavarovanih območij v državah Evropske zveze, ki se imenuje Natura 2000.

V prispevku je opravljena primerjava posledic za varstvo narave, še posebej varstvo mokrišč v okviru omrežja Natura 2000, po sprejemu smernic Evropske zveze o skupni politiki do voda:

Vzpostavljena je jasna povezava med naravovarstveno zakonodajo in predpisi s področja porečij.

Smernice Evropske zveze o skupni politiki do voda (Water Framework Directive) povezuje tudi ekološko stanje voda v pogledu biotske raznovrstnosti (in ne le kakovosti in vodnih količin).

Inventar območij v omrežju Natura 2000 in vzdrževanje njihovega ekološkega značaja je predpogoj pri načrtovanju ukrepov na ravni porečja.

Smernice Evropske zveze o skupni politiki do voda zahtevajo učinkovito spremljanje stanja v omrežju Natura 2000.

Zahteva smernic Evropske zveze o skupni politiki do voda po "dobrem ekološkem stanju voda" ponuja možnosti za ekološko obnovo mokrišč (v smislu samočistilne sposobnosti mokrišč in možnosti naravnega zadrževanja voda).

Pri pripravi načrta upravljanja porečja smernice Evropske zveze o skupni politiki do voda zahtevajo tudi ekonomske analize rabe vode; ta ukrep naj bi pripomogel tudi k obnovi naravnih procesov v mokriščih, saj je to najbolj učinkovita rešitev zagotavljanja "dobrega ekološkega stanja voda".

V prispevku je podan tudi kratek opis organiziranosti vodnega gospodarstva in varstva mokrišč v Sloveniji, skupaj s kratkim pregledom obsega in tipov mokrišč.

Ključne besede: vodno gospodarstvo, varstvo narave, mokrišča, Evropska zveza, smernice Evropske zveze o skupni politiki do voda, ptičje smernice, habitatne smernice, Slovenija

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Uradni list RS (2002): Zakon o vodah. UL RS št. 67/02.

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OWL-FLY *LIBELLOIDES MACARONIUS* (SCOPOLI, 1763) IN SLOVENIA AND IN THE NORTHWESTERN PART OF CROATIA (NEUROPTERA: ASCALAPHIDAE)

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ABSTRACT

The distribution and biology of the European ascalaphid species Libelloides macaronius *(Scopoli) in Slovenia, Croatian Istria and Quarnero is presented. With the aim to investigate the diet of the owl-fly species, the digestive tract contents were examined. Remains of aphids, bugs, cockroaches, beetles, neuropterans and dipterans were found.*

Key words: *Libelloides macaronius,* owl-flies, Neuroptera, distribution, Slovenia, Istria, Quarnero, phoresy, diet

ASCALAFO *LIBELLOIDES MACARONIUS* (SCOPOLI, 1763) IN SLOVENIA, ISTRIA E QUARNERO (NEUROPTERA: ASCALAPHIDAE)

SINTESI

L'articolo presenta un resoconto di distribuzione e biologia dell'Ascalafide europeo Libelloides macaronius *(Scopoli) in Slovenia, Istria e Quarnero. Gli ascalafi sono predatori polifagi che si nutrono di afidi, cimici, scarafaggi, scarabei, neurotteri e ditteri. L'articolo include anche note sulla predazione di ascalafi e sulla foresi.*

Parole chiave: *Libelloides macaronius,* ascalafi, Neuroptera, distribuzione, Slovenia, Istria, Quarnero, foresi, alimentazione

INTRODUCTION

Owl-flies (Ascalaphidae) are medium-sized to large neuropterans, widely distributed in tropical and subtropical regions. About 400 species in ca. 70 genera are known (Aspöck *et al.*, 2001). In Europe, 16 species have been recorded (Aspöck *et al.*, 2001). In the northwestern part of the Balkan Peninsula, 3 species in 2 genera occur: *Deleproctophylla australis* (Fabricius, 1787), *Libelloides lacteus* (Brullé, 1832) (syn. *Libelloides ottomanus* /Germar, 1839/) and *Libelloides macaronius* (Scopoli, 1763) (Aspöck *et al.*, 1980, 2001; Devetak, 1992, 1995, 1996).

Libelloides macaronius was described in Scopoli's Entomologia carniolica in 1763 as *Papilio macaronius*. Later, the species was placed in the genus *Ascalaphus* Fabricius, 1775, and in 1972, Tjeder placed the species in the genus *Libelloides* Schäffer, 1763. *Libelloides macaronius* is polycentric Ponto-Mediterranean element known from Central, Eastern and Southern Europe and from the Palearctic region of Asia (Aspöck *et al.*, 1980; 2001). In the Balkan countries, the species is widely distributed (Devetak, 1992).

Adult and larval morphology of *L. macaronius* was thoroughly investigated. According to the high variability in wing-coloration patterns, a few subspecies were described but their taxonomic status is still uncertain (Aspöck *et al.*, 1980, 2001). The larva of *L. macaronius* was described by Pieper & Willmann (1980).

Owl-flies are diurnal predators able to fly at high velocities in pursuit of small insects. They grasp their prey in flight using strong legs, and mandibles enable them to feed even on strongly sclerotised insects. From the intestinal contents one can speculate on the food supply of the animal investigated.

Since 1965 and 1967, when Gogala & Michieli (1965) and Gogala (1967) published their papers on ultraviolet sensitivity of the ascalaphid superposition eyes, a series of papers elucidating the mechanisms involved in UV vision has been published (for review see Stušek *et al.*, 2000; Drašlar & Wolfrum, 2001; Kral, 2002). This unique sensitivity of the ascalaphid eyes is the reason why the owl-fly species *L. macaronius* has become a well-known experimental animal (Fig. 2).

In the Republic of Slovenia, L. *macaronius* is treated as endangered species. The aim of our study is to present information on the biology and distribution of the owl-fly in Slovenia and in the northwestern part of Croatia.

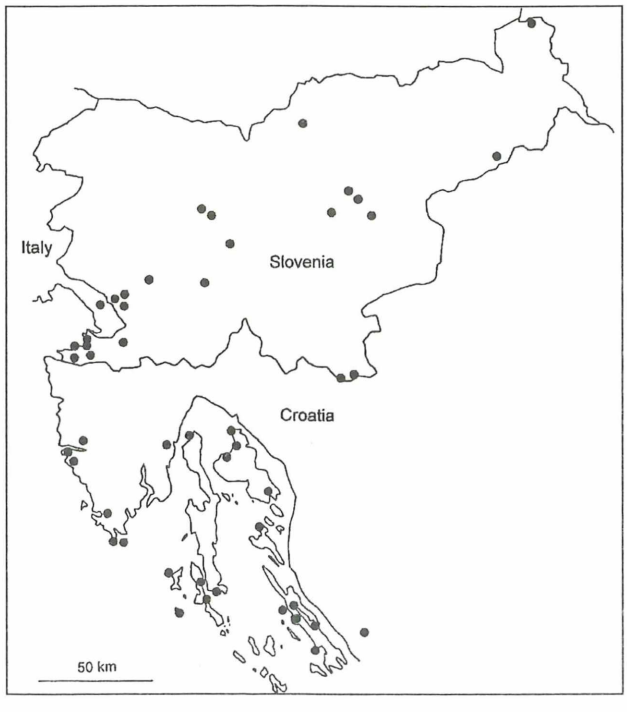


Fig. 1: Distribution of** L. macaronius **in Slovenia, Istria and Quarnero based on the owl-flies collected after 1950.
Sl. 1: Razširjenost metuljčnic** L. macaronius **v Sloveniji, Istri in v Kvarnerju glede na primerke, zbrane po letu 1950.

MATERIAL AND METHODS

Dried or in alcohol preserved adults from insect collections in the following institutions were examined: Natural History Museum of Slovenia (Ljubljana), Slovenian Academy of Science and Art (Ljubljana), Croatian Natural History Museum (Zagreb) and D. Devetak's collection (Maribor). The owl-flies were collected by the following persons: J. Ahtik (JA), J. Carnelutti (JC), A. Ćehić (AĆ), D. Devetak (DD), M. Devetak (MD), M. Frankvić (MF), V. Furlan (VF), I. Hafner (IH), M. Hafner (MH), F. Janžekovič (FJ), M. Jež (MJ), M. Kaligarič (MK), K. Kirbiš (KK), B. Kmecl (BK), V. Lesjak (VL), I. Lešnik (IL), B. Mencinger (BM), F. Perović (FP), P. Pirš (PP), J. Staudacher (JSta), J. Stussiner (JStu), A. Šentjurc (AŠ), P. Tonkli (PT) and M. Zavec (MZ).

The wings of the owl-flies from Petrinje and Pomjan were measured and analysed using descriptive statistics. The insects were collected in June and July 1996.

To investigate the digestive tract content, 25 adults from Petrinje, preserved in 70% alcohol, were dissected and the intestine was isolated. The masticated food remains suspended in alcohol were mounted on glass slides and examined microscopically. A few preparations were stained with methylene blue. The best results were obtained without staining.

In the field, activity of the owl-flies was recorded with the Sony video camera recorder CCD-TR750E. The plant communities of the meadows near Petrinje were documented; for terminology of the species see Martinčič *et al.* (1999).

RESULTS

Distribution of *L. macaronius* in the northwestern part of the Balkan Peninsula

Literature records: Kačírek (1998): the island of Krk: Baška, Jurandvor, Malinska, Njivice, Omišalj; Táborský (1936): the island of Krk; Táborský (1939): Šmarna gora.

Material examined (for the abbreviations used see Material and methods) (Fig.1):

Italy:

Trieste/Trst: Villa Opicina/Opčine, 26. VI. 1973 (PT).

Slovenia:

Ankaran, 27.-29. VII. 1982 (MZ); Bela krajina: Damelj, 4. VII. 1980 (DD); Bela krajina: Vinica, 5. VII. 1980 (DD); Cerknica, Menišija, 10. VII. 1966 (JC); Dragonja, 17. VI. 1996 (DD, FJ, BM, PP); Goričko: Čepinci, 28. VI. 1997 (DD); Haloze: Cirkulane, 29. VI. 1997 (DD); Izola, VI. 1982 (MK); Koper, Srmin, VII. 2002 (MD); Krim, Gornji Ig, 7. VII. 1974 (PT); Kum, 2. VIII. 1918 (MH); Kurešček, Zapotok, 24. VII. 1921 (JStu); the surroundings of Laško, 30. VII. 1970 (IL); Laško, Govce, 6. VII. 1980 (IL); Laško, Šmohor, 11.-14. VII. 1990 (BK); Lisca, 10. VII. 1972 (JA); Ljubljana, along the Sava banks, 18. VI. 1932 (IH); Ludranski vrh, Najevnik (1000 m altitude), 27. VII. 1980 (MJ); Medvode, Preska, 25. VI. 1910, 1. VII. 1923, 29. VI. 1929, 22. VI. 1930 (MH); Nanos, 24. VII. 1983 (AŠ); Petrinje, nad Črnim Kalom, 12. VII. 1974 (DD), 14. VII. 1975 (DD), 16. VI. 1976 (DD), 26. VIII. 1980 (DD), 11. VII. 1982 (DD), 14.-18. VI. 1996 (DD, FJ, BM, PP), 20. VII. 1996 (AĆ, KK, PP); Pod Stolom, 27. VII. 1919 (MH); Polhograjski Dolomiti: Grmada, 25. VII. 1982 (VF); Polhograjski Dolomiti: Topol, 19. VI. 1932 (JSta); Pomjan, 17. VI. 1996 (DD, FJ, BM, PP); Sežana, 22. VII. 1981 (DD); Sežana: Povir, 17. VIII. 1982 (DD); Sežana: Štorje, 22. VII. 1981 (DD); Sorško polje, Godeška Dobrava, 10. VI. 1923 (MH); Begunjščica, 10. VIII. 1919 (MH).

*Fig. 2: **Owl-fly** Libelloides macaronius **(Scopoli, 1763) in copula. (Photo: T. Makovec)***
*Sl. 2: **Metuljčnica** Libelloides macaronius **(Scopoli, 1763) med parjenjem. (Foto: T. Makovec)***

Croatia - Istria:

Kamenjak, 12.-15. VII. 1996 (DD); Limski kanal, 16. VI. 1989 (DD); the island of Fenera, VII. 1996 (DD); Pula, 10.-15. VI. 1979, 6.-8. VII. 1983 (BK, AŠ); Rovinj, 4. VI. 1985 (DD); Rovinj, Valalta, 10. VI. 1988 (DD); Vozilići, 27. VI. 1974 (FP).

Croatia - Quarnero:

The island of Cres: Punta Križa, VI. 2002 (DD); the island of Cres, Uvala Banja, 5. VII. 1987 (MF); the island of Krk, Voz-Omišalj, 8. VI. 1938 (JSta); the island of Lošinj, VI. 1974 (VF), 7. VII. 1974 (PT); the island of Lošinj, Ćunski, VII. 1974 (VF, PT), VII. 1987 (VF); the island of Lošinj: Nerezine, VI. 1999, VI. 2001, VI. 2002 (DD); the island of Pag, Caska, 23. VI. 1956, 5. VII. 1960; the island of Pag, Kolansko Blato, 11. VI. 1958; the island of Pag: Novalja, 29. VI. 1955; the island of Pag, Pag, VII. 1960, 15. VI. 1979 (VL); the island of Pag, Zaglav, VI. 1956; the island of Rab, Lopar, 21. VI. 1976 (DD); the island of Susak, 19. VI. 1962; the island of Unije, 4.-7. VII. 1964.

Length and width of the wings from Petrinje and Pomjan (Slovenia)

Means and standard deviations of length and width of the wings for both sexes and the results of F-test (ANOVA) comparisons of means between sexes are given in Table 1. Means of the males were found to be significantly smaller than in the females.

Tab. 1: Length and width of the wings of** L. macaronius **from Petrinje and Pomjan (in millimetres).
Tab. 1: Dolžina in širina kril metuljčnic** L. macaronius, **ujetih v Petrinjah in Pomjanu (v mm).

		Petrinje		Pomjan		F-test	
		males n=53	females n=40	males n = 8	females n=13	$F_{1,112}$	P
forewings	length	20.5 ± 0.5	23.5 ± 1.0	21.5 ± 1.0	23.0 ± 1.0	204.23	<0.0001
	width	6.5 ± 0.5	7.5 ± 0.5	7.0 ± 0.5	7.5 ± 0.5	161.88	<0.0001
hindwings	length	17.5 ± 0.5	19.5 ± 1.0	18.0 ± 1.0	19.5 ± 1.0	146.30	<0.0001
	width	6.5 ± 0.5	7.5 ± 0.5	7.0 ± 0.5	7.5 ± 0.5	159.81	<0.0001

***Tab. 2: Insect fragments extracted from the digestive tract of** L. macaronius.*
***Tab. 2: Delci žuželk iz prebavnega trakta metuljčnic** L. macaronius.*

Insect order / suborder, family	structure / body part
Blattaria	Legs
Homoptera: Aphidoidea	complete aphids, legs
Hemiptera: Heteroptera	compound eyes, legs
Neuroptera: Chrysopidae	Antennae
Diptera	Legs
Coleoptera	antennae, mouthparts, chitinous plates

The digestive tract content

Well-chewed and partially digested insect fragments were found in the digestive tract (Figs. 5-9). In most cases it was impossible to determine the origin of the rest. Fragments of various body parts of different insect orders were found (Tab. 2). From two adults, fragments of plant tissues were isolated (Fig.10).

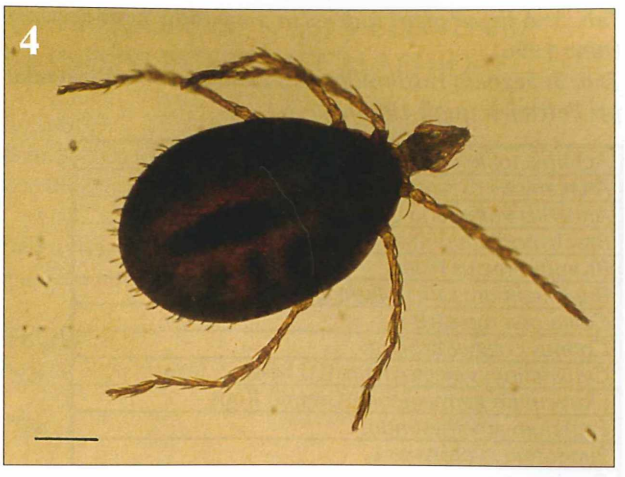
Remarks on the habitats

L. macaronius occurs in meadows, pastures and scrubs. In the Mediterranean part of Slovenia and Croatia, the owl-fly is often found in steppe with *Stipa* as a dominant grass genus.

In the surroundings of Petrinje (Karst edge/Kraški rob), the adults were recorded in two habitats, in a scrub community and in grassland (Fig. 3). In the scrub, the dominant species were *Juniperus communis* and *Stipa pulcherrima*, and in grassland the characteristic and dominant species was *Bromus erectus*. Plant species occurring in the grassland at Petrinje in June 1996 are listed in Table 3. In the Petrinje habitats, insects of fifteen orders were recorded and most of them are a potential prey to *L. macaronius*. In The Petrinje meadows and scrubs, the following neuropteran species were also collected from low vegetation: *Semidalis aleyrodiformis* (Stephens), *Hemerobius gilvus* Stein, *H. handschini* Tjeder, *Chrysoperla lucasina* (Lacroix), *Chrysopa walkeri* McLachlan, *Ch. phyllochroma* Wesmael, *Ch. pallens* (Rambur), *Dichochrysa abdominalis* (Brauer) and *D. zelleri* (Schneider).

Fig. 3: Meadows near Petrinje, June 1996.
Sl. 3: Travniki v bližini Petrinj, junij 1996.
Fig. 4: A nymph of a mite from the family Erytraeidae. Scale bar = 200 µm.
Sl. 4: Ličinka pršice iz družine Erytraeidae. Merilo = 200 µm.
Fig. 5: A cockroach's tarsus with the pectinate claw (order Blattaria). Scale bar = 200 µm.
Sl. 5: Ščurkov tarzus z glavnikastim kremplјem (red Blattaria). Merilo = 200 µm.
Fig. 6: Remainder of an aphid (order Hemiptera, Homoptera). Scale bar = 200 µm.
Sl. 6: Ostanek listne uši (red Hemiptera, Homoptera). Merilo = 200 µm.
Fig. 7: A fragment of the antenna (? order Coleoptera). Scale bar = 200 µm.
Sl. 7: Delček tipalke (? red Coleoptera). Merilo = 200 µm.
Fig. 8: Dipteran tarsal segments; the claws, empodium and pulvilli are recognized (order Diptera). Scale bar = 200 µm.
Sl. 8: Segmenti tarza dvokrilca, z dobro vidnimi kremplji, empodijem in pulvilli (red Diptera). Merilo = 200 µm.
Fig. 9: Corneal lenses of a bug's compound eye (order Heteroptera). Scale bar = 200 µm.
Sl. 9: Kornealne leče steničinega mrežastega očesa (red Heteroptera). Merilo = 200 µm.
Fig. 10: Fragments of plant tissues. Scale bar = 100 µm.
Sl. 10: Delci rastlinskih tkiv. Merilo = 100 µm.


3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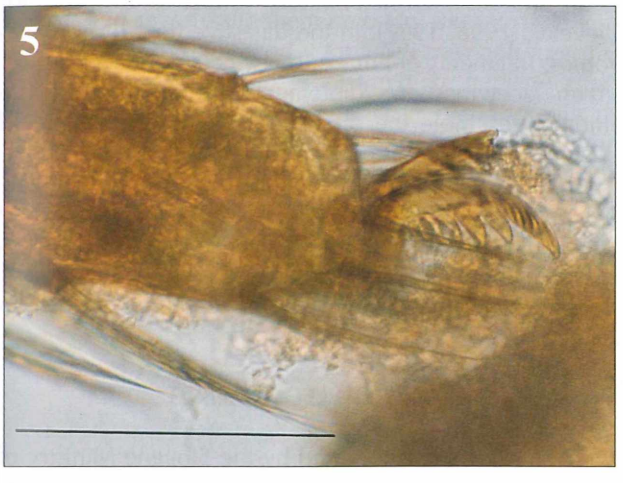
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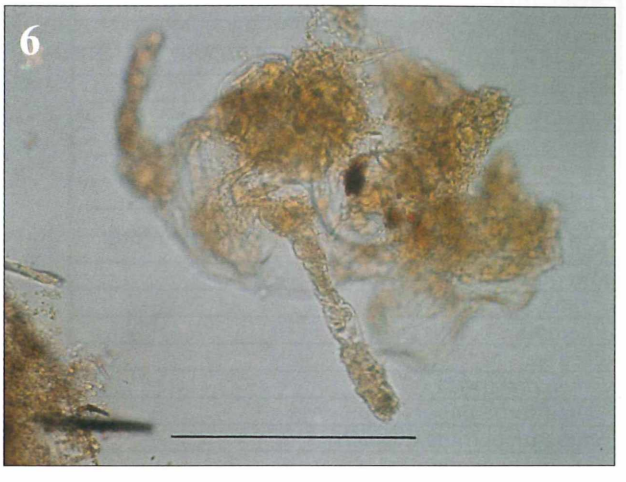
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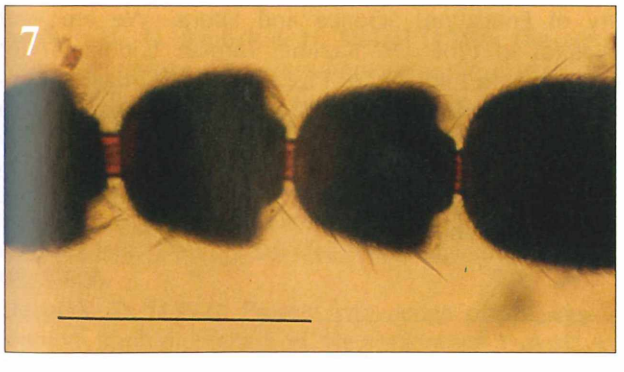
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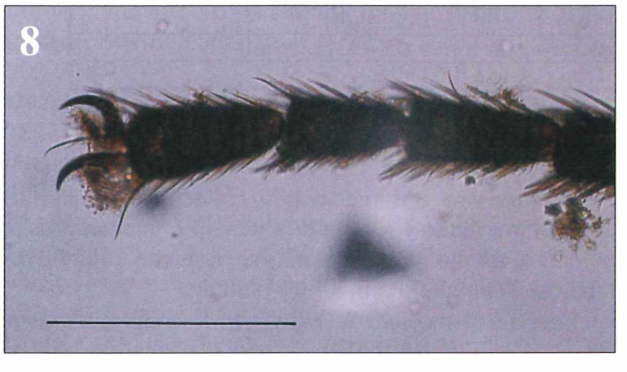
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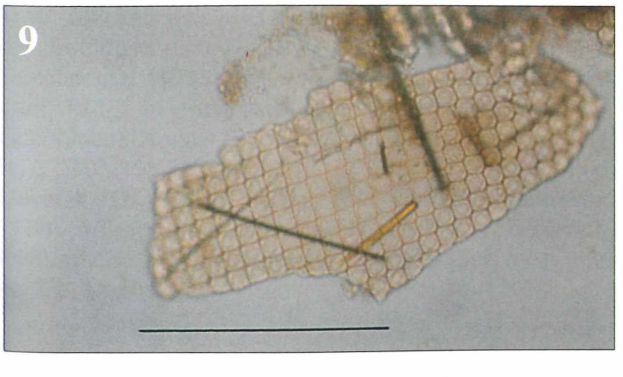
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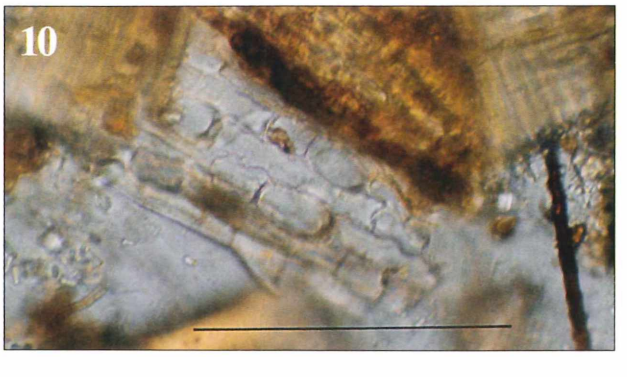
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Tab. 3: A list of plant species in a meadow near Petrinje (June 1996).
Tab. 3: Seznam rastlinskih vrst, zabeleženih na travniku pri Petrinjah (junij 1996).

Achillea millefolium L.
Anacamptis pyramidalis (L.) L.C. Rich.
Anthyllis vulneraria L.
Brachypodium pinnatum (L.) P. Beauv.
Bromus erectus Huds.
Buphthalmum salicifolium L.
Centaurea rupestris L.
Cotinus coggygria Scop.
Cynanchum vincetoxicum (L.) Pers.
Dorycnium germanicum (Gremli) Rouy
Eryngium amethystinum L.
Euphorbia cyparissias L.
Fraxinus ornus L.
Galium verum L.
Helleborus multifidus Vis.
Juniperus communis L.
Knautia illyrica Beck
Ligustrum vulgare L.
Linum tenuifolium L.
Melica ciliata L.
Pinus nigra Arnold
Plantago argentea Chaix.
Polygala nicaeensis Risso
Potentilla tommasiniana F. Schultz.
Prunus mahaleb L.
Rhamnus saxatilis Jacq.
Rosa sp.
Salvia pratensis L.
Sanguisorba minor Scop.
Stipa pulcherrima C. Koch
Teucrium montanum L.
Teucrium chamaedrys L.
Thymus longicaulis C. Presl.
Tragopogon tommasinii C.H. Schultz.
Trinia glauca (L.) Dum.

Notes on phoresy and spider predation

Phoresy was observed while collecting ascalaphids at Petrinje in June 1996. In one female *L. macaronius,* a nymph of a mite from the family Erytraeidae (Fig. 4) was recorded, clung to the owl-fly's hindleg.

Despite of the fact that the owl-flies are predators, they can easily become prey especially when resting on plants. In the field, they were observed while becoming a prey to birds and spiders. At Petrinje, an owl-fly male became a victim in June 1996 of an unidentified jumping spider (Salticidae).

DISCUSSION

Owl-fly *Libelloides macaronius* is widely distributed in Istria and Quarnero, and occurs also in certain warmer places in Slovenia. This ascalaphid prefers open habitats - meadows, pastures and scrub communities with low bushes. Grassland is inhabited by a number of insects from 15 orders that serve as potential prey of *L. macaronius.*

Adults are polyphagous daytime active predators, highly adapted for capturing prey in flight. Ascalaphids are able to prey upon sclerotised insects because of their strong jaws. This ability is contrary to some green lacewings (Chrysopidae), which are specialised to feed on soft-bodied insects such as aphids (Stelzl, 1991; Stelzl & Devetak, 1999), but resembles the feeding habits of adult antlions (Myrmeleontidae) (Stelzl & Gepp, 1990; Devetak, 1996, 1997). In the digestive tract of *L. macaronius,* fragments of aphids, bugs, cockroaches, beetles, green lacewings and dipterans were recorded. These findings resemble the prey-spectrum in closely related species *Libelloides coccajus* (Denis & Schiffermüller, 1763), where dipterans, coleopterans and hymenopterans are predominant prey (Stelzl, 1991). In both owl-fly species, fragments of plant tissues were also found. This plant material probably originated from the intestinal content of the herbivorous insects captured by the ascalaphids.

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METULJČNICA *LIBELLOIDES MACARONIUS* (SCOPOLI, 1763) V SLOVENIJI IN SEVEROZAHODNEM DELU HRVAŠKE (NEUROPTERA: ASCALAPHIDAE)

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POVZETEK

Za navadno metuljčnico, Libelloides macaronius *(Scopoli, 1763), navajamo podatke o biologiji in razširjenosti v Sloveniji in severozahodnem delu Hrvaške. Vrsta je v mediteranskem območju splošno razširjena, v celinskem delu Slovenije pa živi ponekod v toplejših travnatih in grmiščnih habitatih. Metuljčnica poseljuje travnike in grmišča; v mediteranskem območju je za travniške habitate značilna trava iz rodu* Stipa. *Na osnovi vsebine prebavila smo sklepali o prehranskem spektru vrste. V preiskanih metuljčnicah smo našli ostanke listnih uši, stenic, ščurkov, hroščev, mrežekrilcev in dvokrilcev. Zabeležili smo primer forezije, ko se je pršica iz družine Erytraeidae transportirala na samici. Metuljčnice so plen ptic in pajkov.*

Ključne besede: *Libelloides macaronius*, metuljčnice, Neuroptera, razširjenost, Slovenija, Istra, Kvarner, forezija, prehrana

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POND PREFERENCE BY AMPHIBIANS (AMPHIBIA) ON THE KARST PLATEAU AND IN SLOVENIAN ISTRIA

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ABSTRACT

Some habitat determinants and related presence of amphibians in 7 karst ponds in Slovenian Istria and 10 ponds on the Karst Plateau were surveyed from March to August 1999. The presence of different species of amphibians was established by sampling according to standard methods for amphibians. 9 amphibian species were recorded in the surveyed ponds. A canonical correspondence analysis was carried out to determine amphibian habitat preference. 6 species and 14 habitat determinants were included in the analysis. The type of terrestrial habitat near the ponds and the vegetational cover of the water surface in July seemed to be the most important habitat determinants. The presence of fish in ponds was important, too. The European Tree Frog and the Edible Frog turned out to be the most selective species in terms of habitat preference.

Key words: amphibians, Amphibia, karst pond, habitat determinants, canonical correspondence analysis

SCELTA DELLO STAGNO NEGLI ANFIBI (AMPHIBIA) DEL CARSO E DELLA COSTA SLOVENA

SINTESI

Da marzo ad agosto del 1999, l'autrice ha raccolto dati inerenti la presenza di anfibi nonché i valori di determinati fattori ambientali in sette stagni situati sulla costa slovena e dieci stagni carsici. La presenza di diverse specie di anfibi é stata determinata con la metodologia standard per il campionamento di anfibi. Negli stagni ricercati sono state registrate nove specie di anfibi. Per determinare le preferenze di habitat degli anfibi é stata usata l'Analisi Canonica delle Corrispondenze. Nell'analisi sono state incluse sei specie e quattordici fattori ambientali. Le caratteristiche ambientali più importanti sono risultate il tipo di habitat terrestre in prossimità degli stagni e la copertura vegetale sulla superficie dell'acqua in luglio. Molto importante é risultata anche la presenza di pesci negli stagni. Nella scelta dello stagno le più selettive si sono dimostrate la raganella (Hyla arborea) *e le specie appartenenti al gruppo delle rane verdi.*

Parole chiave: anfibi, Amphibia, stagno carsico, fattori ambientali, Analisi Canonica delle Corrispondenze

INTRODUCTION

Artificial water bodies, called karst ponds, were built in the past in Slovenian Istria and on the Karst Plateau to retain rainwater. They were used as water supply for the cattle, for watering and washing and sometimes even for obtaining the ice (Dolce *et al.*, 1991; Lešnik *et al.*, 2000). Today the fast natural succession of overgrowing and drying out of the ponds is accelerated by human destructive activity (Alberti, 1985). Various authors (Polli & Alberti, 1969; Alberti, 1985; Dolce *et al.*, 1991; Grošelj, 1993; Kalc, 1993; Vardjan, 1994; Bressi & Stoch, 1999; Poboljšaj & Kotarac, 1999; Lešnik *et al.*, 2000) have written a number of articles about the significance of karst ponds today and in the past, as well as about the problem of their gradual disappearance.

In the environments where water bodies are scarce or even nonexistent, karst ponds are important habitats for aquatic plants and animals. One of the most endangered (Vidic, 1992; Gregori, 1996) animal groups that share this aquatic habitat are the amphibians. A lot of biotic and abiotic factors influence the amphibian choice of karst ponds as breeding sites and summer habitats. Several authors (Beebee, 1985; Pavignano, 1988; Pavignano *et al.*, 1990; Ildos & Ancona, 1994) studied these factors, attempting to establish how they affect habitat preference. Beside basic requirements as the living space, water quality, food availability and protection from predators, some other more specific conditions are needed for the existence of amphibian species (Oldham & Swan, 1997).

Factors that determine the suitability of a certain water habitat are complex and diverse (Beebee, 1985; Pavignano *et al.*, 1990). Some of the habitat determinants as the presence of aquatic and marshy vegetation, the type of terrestrial habitat near the pond, the age of the pond and the rate of human impact can considerably affect the success of amphibian breeding (Pavignano *et al.*, 1990).

Even species known as ecological generalists (*e.g.* Edible Frog (*Rana kl. esculenta* Linnaeus, 1758) and Common Toad (*Bufo bufo* Linnaeus, 1758), appear to be selective in terms of breeding site choice (Ildos & Ancona, 1994). Nevertheless, according to some surveys, the Edible Frog and the Common Toad are less demanding in terms of breeding habitat selection in comparison with the Agile Frog (*Rana dalmatina* Bonaparte, 1840), European Tree Frog (*Hyla arborea* Linnaeus, 1758), Smooth Newt (*Triturus vulgaris meridionalis* Boulenger, 1882) and Italian Crested Newt (*T. carnifex* Laurenti, 1768), which have more specific requirements (Pavignano *et al.*, 1990).

Beebee (1985) established the importance of geological structure of the ground and type of terrestrial habitat in the pond surroundings, while the type of vegetation cover and overgrowing of the pond were set out as the most important habitat features by Ildos & Ancona (1994). Chemical and physical characteristics of the water (*e.g.* pH, conductivity) seem not to be as important for amphibians as other environmental characters (Beebee, 1985). Nevertheless, if these characteristics appeared to be important, this was then due to the aquatic vegetation conditions (Ildos & Ancona, 1994).

On the Italian side of the Karst Plateau, ponds are being carefully studied and are subject of a certain degree of protection and/or management (Bressi & Stoch, 1999). In the absence of similar studies in Slovenia, the objective of the present study was to illuminate the importance of these unique water bodies as breeding habitats for the survival of amphibians.

MATERIAL AND METHODS

In the period between March and August 1999, 7 ponds along the Slovenian coast and 10 ponds on the Karst Plateau were surveyed in order to find habitat determinants important for amphibians. The investigated ponds were chosen on the basis of various criteria: vicinity of an urban area, vicinity of other ponds, shape and structure of the ponds (*e.g.* bottom type, depth, bank inclination and presence of rocky walls), quantity of aquatic vegetation and presence of fish. Geographic positions of the investigated ponds as well as of other karst ponds in the surveyed area are shown in Figure 1. The investigated ponds are labelled "I" for Istria, "K" for Karst and numbered. The list of surveyed ponds is shown in Table 1.

Ponds were visited once a week from March 11, in the period of the initiation of spring migrations to breeding sites, to August 18, when most amphibians were already metamorphosed and when many ponds had dried up. Data collected during the fieldwork and used for successive analysis were as follows: pond area (m^2), depth (m) and bottom type, water transparency, presence of fish, minimal and maximal bank inclination (°), extent of aquatic vegetation cover in April and July (%), average distance from ruts, roads and houses (m), percentage of grassland, wood, arable land and urban area in the pond's surrounding (100 m). Most of these parameters are numerical, while water transparency, bottom type and presence of fish are attributive parameters that were evaluated as follows: 1 was used for silt bottom, 2 for mixed silt and rocky bottom, 3 for rocky bottom and 4 for concrete. In case fish were present in the pond, No. 1 was used, while fishless ponds were evaluated with 0. Water transparency was only estimated and Nos. from 1 to 3 were used, 1 indicating water transparency of a few centimetres, 2 medium transparency, and 3 completely transparent water.

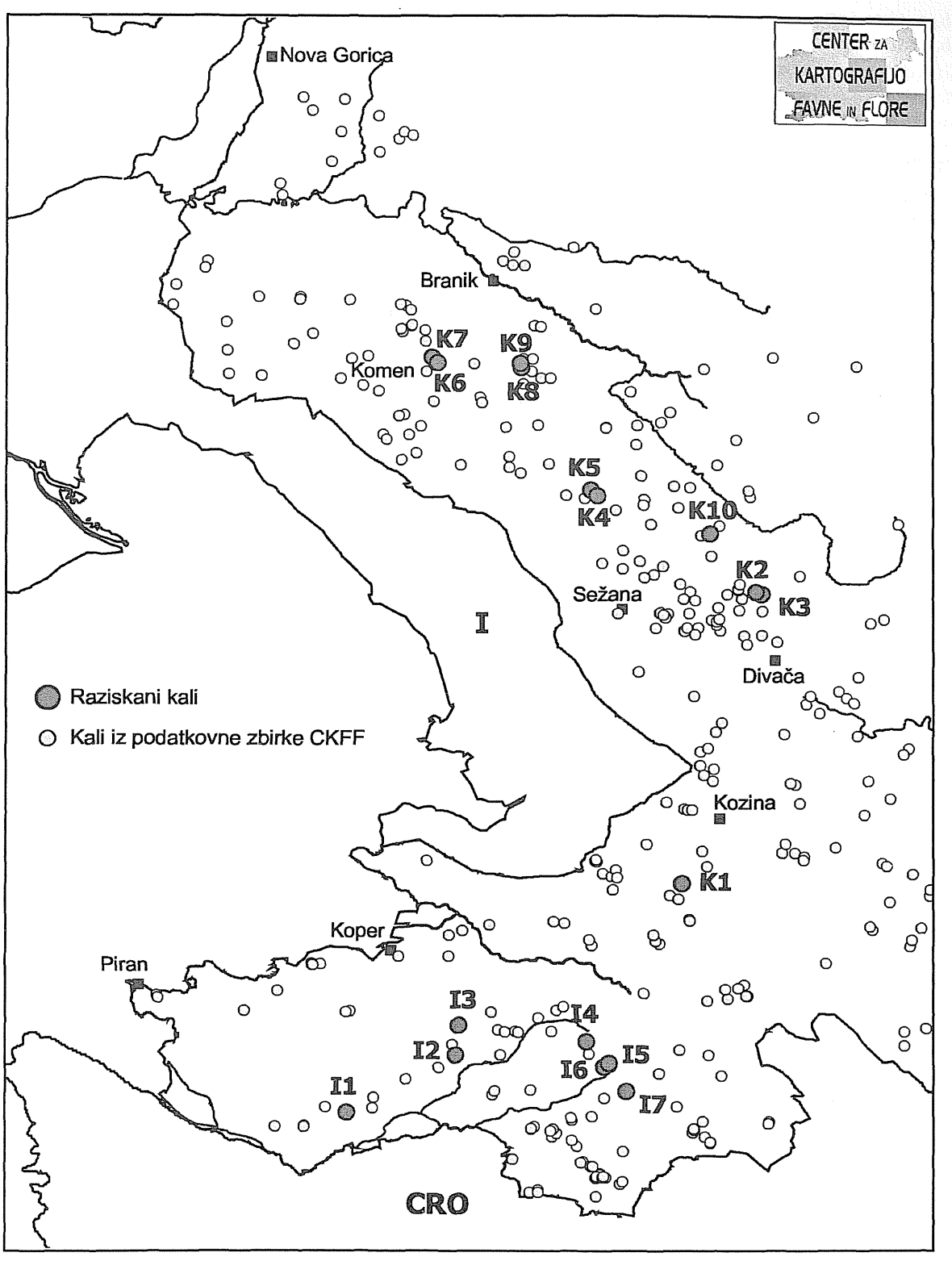

Fig.1: Map of the surveyed area with presently recorded karst ponds from database by courtesy of the Centre for Cartography of Fauna and Flora (CKFF). The surveyed ponds are indicated with larger circles and numbers.
Sl. 1: Karta območja raziskave z do sedaj evidentiranimi kali iz podatkovne zbirke Centra za kartografijo favne in flore (CKFF). Raziskani kali so označeni z večjimi krogi in številkami.

Tab. 1: List of 17 surveyed ponds in Slovenian Istria and on the Karst Plateau.
Tab. 1: Seznam 17 obravnavanih kalov v Slovenski Istri in na Krasu.

Ponds in Slovenian Istria		Ponds on the Karst Plateau	
		K1	Pond "Na potoku" near Petrinje
		K2	Pond "Globočaj" near Brestovica pri Povirju
		K3	Pond "Kalužca" near Brestovica pri Povirju
I1	Pond "Pri kalu" near Krkavče	**K4**	Pond at Tomaj
I2	Pond at Rojci	**K5**	Pond near Tomaj
I3	Pond "Pri Lokvi" near Mali Čentur	**K6**	Pond at Divči near Komen
I4	Pond near Hrib	**K7**	Pond in old nursery at Komen
I5	Big pond near Poletiči	**K8**	Old pond at Kobjeglava
I6	Small pond near Poletiči	**K9**	Renewed pond at Kobjeglava
I7	Pond at Gračiška Vala	**K10**	Pond "Šafarjev kal" at Štorje

Tab. 2: Input data for the canonical correspondence analysis (CCA): presence, estimated abundance and breeding success of amphibian species in ponds in Slovenian Istria and on the Karst Plateau. 0: species not present in pond, 1: presence of some adult individuals or in some cases of other developmental stages, 2: presence of individuals of different developmental stages, mostly of adults and spawn or eggs, 3: presence of a middle number of adults, eggs or spawn and larvae, 4: presence of a high number of adults, eggs or spawn and larvae, 5: presence of a high number of adults, eggs or spawn and larvae and/or confirmed metamorphosis in juveniles.
Tab. 2: Vhodni podatki za kanonično korespondenčno analizo: zastopanost, ocenjena številčnost in uspešnost razmnoževanja vrst dvoživk v kalih v Slovenski Istri in na Krasu. 0: vrsta ni zastopana, 1: zastopanost posameznega odraslega osebka, v nekaterih primerih pa drugega razvojnega stadija, 2: posamezna zastopanost več razvojnih stadijev, največkrat odraslih in mrestov, 3: zastopanost srednjega števila odraslih, mrestov oz. jajc in ličink, 4: zastopanost velikega števila odraslih, mrestov oz. jajc in ličink, 5: zastopanost velikega števila odraslih, mrestov oz. jajc in ličink in/ali potrjena preobrazba v mladostne osebke.

	Triturus carnifex	*T. vulgaris meridionalis*	*Bufo bufo*	*Hyla arborea*	*R. esculenta* complex	*Rana dalmatina*
I1	0	0	1	0	0	0
I2	3	0	0	4	0	2
I3	4	3	0	3	0	0
I4	0	0	0	0	0	0
I5	0	0	5	1	0	5
I6	1	5	0	2	0	1
I7	5	5	0	5	0	5
K1	3	5	3	3	3	5
K2	4	5	2	5	5	5
K3	3	5	0	0	3	5
K4	3	1	5	0	0	5
K5	0	1	2	0	0	3
K6	1	2	5	0	0	5
K7	1	3	5	0	0	5
K8	1	1	4	0	0	1
K9	1	1	3	0	0	1
K10	0	0	4	0	1	2

The presence and abundance of different species of amphibians were established by sampling according to standard methods for amphibians (Heyer *et al.*, 1994): for the sampling of newts and adult frogs we used the "Survey at breeding sites" method, while for the sampling of tadpoles the "Quantitative sampling of amphibian larvae" was applied. We used water net with the straight side of 27 cm.

The amphibian species included in the analysis were those commonly found in ponds: Smooth Newt, Italian Crested Newt, Common Toad, European Tree Frog, Agile Frog and species from the Green Frog group *(Rana*

esculenta complex). The species were ranked into 6 classes according to the presence, estimated abundance and reproduction success in specific ponds. Occurrence, abundance and breeding success of each analysed species in 17 ponds are shown in Table 2. A canonical correspondence analysis (CCA) (CANOCO 3.12, ter Braak, 1991) was carried out for the 6 amphibian species and 14 habitat determinants mentioned above.

We performed the Monte Carlo permutation test to establish the statistical significance of the effect of each environmental variable. The test was run with 99 permutations.

RESULTS

The canonical correspondence analysis (CCA) was carried out on 6 amphibian species and 14 habitat determinants from 17 ponds. The CCA method elucidates the relationship between biological assemblages of species and their environment and is used mainly in aquatic ecology studies (ter Braak & Verdonschot, 1995). Several of studied ponds characteristics can be seen from ordination diagram (Fig. 2). Ter Braak & Verdonschot (1995) report the interpretation mode of ordination diagram.

The Monte Carlo permutation test showed that the first ordination axis explains the relationship between species and environmental determinants at the 1% significance level with the F value being 2.57, while for all 4 ordination axes significance was on limit at 5% level (F=2.31, p=0.06, n.s.). However, we can assume that the ordination diagram, which shows only the first two axes, explains the relationship and differences between amphibian species, localities and environmental variables in a satisfactory manner. This assumption is confirmed by the fact that the ordination diagram displays a high percentage of weighted variance in the abundance of species ("inertia"=75%) and a high percentage of variance in the weighted averages and class totals of species with respect to the environmental variables (84%). The first two axes of the ordination diagram display 81.2% of variance of relationship between species and environmental variables (Tab. 3).

Species indicated in the ordination diagram by triangles are arranged according to their abundance and breeding success. Species being closer in the diagram have higher similarity in the distribution than species being more distant from each other. Thus, the Common Toad and the Agile Frog have similar distribution and rate of breeding success in ponds. In this regard, similar distribution can be seen also for the two species of newts as well as for the Italian Crested Newt and the European Tree Frog. The Green Frog group is the most distant from other species in the diagram, as it was found only in 3 ponds. The distance between the Common Toad and the European Tree Frog is also large, reflecting the fact that they occurred in the same pond only in two cases.

Ponds are indicated by circles in the ordination diagram and are arranged according to the values they have in relation to the first two axes. Ponds being closer together are thus more similar in terms of amphibian species composition and their breeding success. Karst ponds (from K4 to K9) turned out to be very similar between each other, while most of the ponds in Slovenian Istria (except I1 and I5) are arranged on the opposite side of the ordination diagram and are not so close together. Pond I4 is missing on the diagram, as none of the amphibian species was present in it.

The relative length of the line representing the determinate environmental variable indicates the importance of this variable. Diagram shows that the most important environmental variables for the distribution of species are those determining the terrestrial habitat in pond vicinity (*e.g.* average distance from roads and houses, presence of arable land and urban area) as well as the extent of the aquatic vegetation in July. Other important variables are water transparency, presence of fish and maximal bank slope. Variables that according to the line length appear to be less important are the extent of aquatic vegetation in April, minimal bank slope and presence of wood in the pond's immediate surrounding. Some other authors (Beebee, 1985; Pavi-

Tab. 3: Some values displayed by the axes of the ordination diagram. The latter displays only the first two axes.
Tab. 3: Nekatere vrednosti, ki jih izkazujejo osi razvrstitvenega diagrama CCA. Razvrstitveni diagram prikazuje le prvi dve osi.

Axes of ordination diagram	Eigenvalues	Correlation between species occurrence and environmental variables	Cumulative percentage of variance of species data	Cumulative percentage of variance of species-environment relation
1st axis	0.363	0.993	56.2	59.9
2nd axis	0.128	0.998	76.1	81.2
3rd axis	0.054	0.913	84.5	90.1
4th axis	0.040	0.904	90.7	96.8

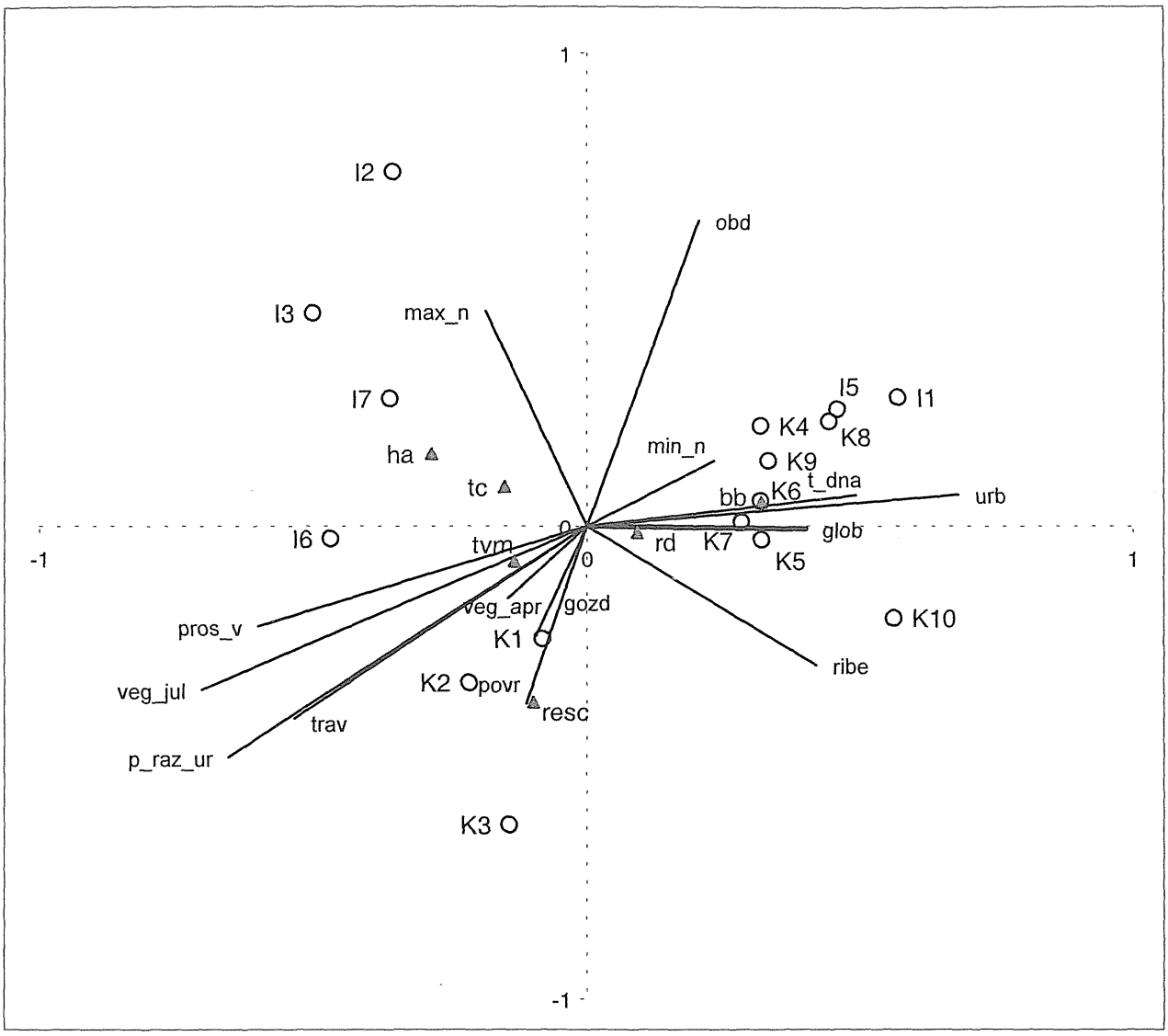

Fig. 2: Ordination diagram of CCA. The eigenvalue of the first axis is 0.36; eigenvalue of the second axis is 0.13. Diagram shows 75% of weighted variance in the abundance of species ("inertia") and 84% of variance in the weighted averages and class totals of species with respect to the environmental variables. Amphibian species (triangles): Tvm–*Triturus vulgaris meridionalis*, Tc–*T. carnifex*, Bb–*Bufo bufo*, Ha–*Hyla arborea*, Rd–*Rana dalmatina* and Resc–*R. esculenta complex*; ponds (circles and pond number); environmental variables (solid lines): povr–pond surface, glob–water depth, pros_v–water transparency, t_dna–bottom type, ribe–presence of fish, min_n, max_n–minimal and maximal bank slope (respectively), veg_apr, veg_jul-extent of aquatic vegetation in April and July (respectively), p_raz_ur–average distance from ruts, roads and houses, trav, gozd, obd, urb-percentage of grassland, wood, arable land and urban area (respectively) in the ponds' surroundings (100 m).

Sl. 2: Razvrstitveni diagram CCA. Lastna vrednost prve osi je 0,36, lastna vrednost druge osi je 0,13. Diagram izkazuje 75% obtežene variance ("inertia") v gostotah vrst in 84% variance v obteženih povprečjih vrst glede na okoljske dejavnike. Vrste dvoživk (trikotniki): Tvm–*Triturus vulgaris meridionalis*, Tc–*T. carnifex*, Bb–*Bufo bufo*, Ha–*Hyla arborea*, Rd–*Rana dalmatina* in Resc–*R. esculenta complex*; kali (krogci in številka kala); okoljski parametri (daljice): povr–površina kala, glob–globina vode, pros_v–prosojnost vode, t_dna–tip dna, ribe–zastopanost rib, min_n, max_n–minimalni in maksimalni naklon brežin, veg_apr, veg_jul- zaraščenost vodne površine v aprilu in juliju, p_raz_ur–povprečna oddaljenost kala od kolovozov, cest in naselij; trav, gozd, obd, urb-odstotek pokritosti neposredne bližine kala (100 m) s travnatimi, gozdnatimi, obdelanimi in urbanimi površinami.

gnano *et al.*, 1990; Ildos & Ancona, 1994) found the same importance of terrestrial habitat near breeding sites and of the extent of aquatic vegetation for the habitat selection among amphibians. Beside this, Beebee (1985) also reports of the importance of geological structure of the ground, the factor we did not include in the analysis.

The arrangement of environmental lines indicates correlation between environmental variables themselves. Correlation is shown by the projection of the free end of the line on the other variable line. If the projection points in the same direction as the line, the correlation is positive, if it points in the opposite direction, the correlation is negative. The ordination diagram thus shows some logical interdependencies. With growing distance from the urban area, there is more grassland and wood in the ponds' vicinity, and ponds are more overgrown with vegetation. On the other hand, when in the vicinity of the populated area, ponds have more arable land in the immediate surrounding and fish are more common in the pond water. In the urban area, ponds are being cleaned up regularly, thus the water in these ponds tends to be deeper than in other ponds. Water transparency has positive correlation with the spread of vegetation in July. This is expected as the aquatic vegetation depletes nutrients from water, which consequently is clearer. The bottom type and the vicinity of the urban area also show positive correlation. In the evaluation of the bottom type, the score was namely growing from silt to concrete bottom. So, with descending distance from the urban area, more ponds have rocky or even concrete bottom.

The effect of a certain environmental parameter on the occurrence of a species is illustrated by the projection of species point on the environmental line. The farther the projection lies on the line to positive or negative direction, the higher is the positive or the negative correlation between parameters and species. Environmental determinants thus do not have a substantial impact on the species that are scattered around the origin (0.0) of diagram (representing the mean value of the environmental variable). In our case, such species are the Agile Frog, Smooth Newt and Italian Crested Newt. However, all relationships between the species, localities and environmental determinants are not expressed in a proper manner, since the diagram shows only the first two ordination axes.

DISCUSSION

The Smooth Newt and the Italian Crested Newt show low but positive correlation with parameters that indicate ponds outside the populated area. Both newts are therefore often found in ponds surrounded by grassland and woods, which are considerably overgrown in July, and appear to prefer shallow water. Similar preferences are reported by Pavignano *et al.* (1990). Nevertheless, differences between the habitat preferences of the two newt species do exist, as the Italian Crested Newt is known as a more demanding species, and in water bodies it is not as common as the Smooth Newt (Pavignano, 1988). However, we found the two newts generally together in ponds and the same was shown by an investigation in northwestern Italy (Pavignano, 1988).

The Italian Crested Newt's preference for deeper ponds with open water and less aquatic vegetation (Pavignano, 1988; Ildos & Ancona, 1994) can be also seen from the ordination diagram. The ordination diagram shows that the vicinity of populated area has a negative impact on the presence of newts in the ponds, as the highest abundance of adult newts and their larvae was found in the ponds far from villages. Results of other studies (Ildos & Ancona, 1994) indicate, on the other hand, that the Smooth Newt is abundant in water bodies inside urban areas. Both species appear to be sensitive to the presence of fish. Although adult newts were also observed in ponds inhabited by fish, they successfully breed only in fishless ponds. Some other authors (Ildos & Ancona, 1994; Andreone, 1998) report the same. Pond I1, where we did not observe any amphibians in 1999, supported a large population of the Italian Crested Newt (Poboljšaj, 1993) before the introduction of fish. A factor that Ildos & Ancona (1994) also report to have negative impact on the newt habitat choice is steep banks. This is not clearly visible from the present study results, which indicate that both species have positive correlation with maximum bank slope. In the same time it appears that newts prefer ponds with gently sloping banks. This apparent nonsense can be explained with the fact that the same pond often has partly steep and partly gently sloping banks. It is thus more probable that newts prefer gently sloping banks that allow them an easy access to the water.

The European Tree Frog is known as a more selective species in terms of breeding site selection than its sympatric species (Beebee, 1996). Pavignano *et al.* (1990) suggest that the typical European Tree Frog's breeding site is a small pond with rich and heterogeneous vegetation. The ordination diagram shows that it has similar requirements as the two newts. Among all species, the European Tree Frog exhibits the highest negative correlation with the presence of fish in the ponds. As local people reported to us, the European Tree Frog's population had bred in the pond K9 in Kobjeglava every year before the introduction of gold fish. A similar case is known from pond I1 near Krkavče: Poboljšaj (1993) reports about the presence of the European Tree Frog in this pond. Bressi & Stoch (1999) also describe this species as sensitive to fish presence. Among the studied ponds, those surrounded by grassland with well-developed aquatic vegetation were usually preferred by the European Tree Frog. Similar results were obtained during the study by Ildos & Ancona (1994). Surprisingly,

the ordination diagram points out that woodland in the pond's vicinity has a negative impact on the presence of the European tree frog. Namely, trees and shrubs are very important terrestrial habitat features for this species, and Stumpel (1999) reports that the European Tree Frog is more sensitive to the suitability of terrestrial habitat, that is to the quality of water body. However, only 100 m zone around the ponds was included in the analysis, while woods and shrub could be present outside this zone but still within reach of the European Tree Frog. It is also possible that on the arid Karst Plateau, the European Tree Frog spends most of the time in the pond's immediate surroundings on aquatic and marsh vegetation and does not migrate to the terrestrial habitat. With regard to the pond area, the ordination diagram displays that the European Tree Frog prefers small ponds with shallow water. This seems to be a common preference of the species since Beebee (1996) and Pavignano *et al.* (1990) obtained the same results.

The present study shows that the species from the Green Frog group are very selective as regards habitat preference. We observed their presence only in 3 Karst ponds. On the other hand, other authors (Pavignano *et al.*, 1990; Ildos & Ancona, 1994) describe Green Frogs as non-selective and very adaptable animals. The only apparent preferences of the Green Frogs are breeding sites with rich aquatic vegetation on geologically older ground (Ildos & Ancona, 1994). The ordination diagram indicates that Green Frogs are the only group of amphibians in this study, which show high positive correlation with water body surface. This probably reflects the fact that Green Frog tadpoles reached metamorphosis only in the pond of Globočaj (K2), which is the largest among all surveyed ponds. The results indicating that Green Frogs select ponds with rich aquatic vegetation and wood in their surroundings resemble those reported by Ildos & Ancona (1994). Beside this, we found positive correlation between Green Frogs' presence and shallow pond water, gently sloping banks and distance from the urban area. Green Frogs exhibit positive correlation with presence of fish as well, showing that fish do not affect their reproduction cycle, as is the case with the newts and the European Tree Frog. Bressi & Stoch (1999) even discovered that in fishponds Green Frogs as well as Common Toads become dominant among amphibians. Nevertheless, it is probable that fish have a negative impact on the development of Green Frog tadpoles. As Green Frog tadpoles could be observed in K1 pond only for a short period of time, it is likely that they ended as fish prey before they reached metamorphosis. A lot of diverse microhabitats with shallow water, where tadpoles can find shelter from predators, allowed Green Frogs' tadpoles to develop and reach metamorphosis in the pond of Globočaj (K2) despite high fish abundance. Ildos & Ancona (1994) even discovered that Green Frogs did not breed at all in water bodies with fish.

The Common Toad is known to be a very adaptable species, too (Giacoma, 1998; Bressi & Stoch, 1999). This has been confirmed by our results as well, for we found this species in a fairly high number of ponds (11). The species was recorded mostly in ponds in or near the urban areas (see the ordination diagram, Fig. 2). The most important breeding habitat feature turned out to be relatively deep water, while the most important terrestrial habitat is arable land. Similar results about the Common Toad's habitat preference are displayed by Beebee (1985), Giacoma (1998) and others. Deep-water bodies are not suitable for snakes and waterfowl that are the main predators of the Common Toad (Ildos & Ancona, 1994). As indicated by the ordination diagram, Common Toad appears to be the only species that showed negative correlation with the extent of aquatic vegetation. However, a detailed examination of the occurrence of Common Toad in ponds revealed that this species bred successfully in ponds with rich vegetation as well as in ponds without it. This again confirms a high adaptability of the Common Toad. Like Green Frogs, Common Toad shows positive correlation with the presence of fish in ponds. Similar results are reported by Beebee (1985). Common Toad tadpoles are thought to be a frequent fish prey only at the very beginning of their development (Giacoma, 1998), while the production of toxins that begins after few weeks make them inedible and therefore not sensitive to fish presence (Beebee, 1986; Giacoma, 1998). Nevertheless, fish probably do affect the development of Common Toad tadpoles as they reached metamorphosis only in two fishponds while in others we did not observe any metamorphosed juveniles. In any case, the ability of the Common Toad to adapt to different environments allows this species to be less sensitive to habitat changes and to disappearing of water bodies in comparison with other amphibian species (Giacoma, 1998).

If we consider the high number of ponds, in which the Agile Frog was present during our survey (14 ponds of 17 examined), this species should be defined as the most adaptable and less selective in terms of habitat preference. Boano (1998), too, describes this frog as one of those adaptable amphibian species, which frequently choose small and often artificial ponds as their breeding sites, as well as ponds that dry out in the summer period. Bressi & Stoch (1999) report that this brown frog species is very common on the Italian side of the Karst Plateau. The central position of the point indicating the Agile Frog on the diagram shows that it has a low correlation with all habitat determinants. It is clear, however, that this frog is more common in ponds with less aquatic vegetation and in those near or in the urban areas. The Agile Frog is relatively insensitive to the presence of fish. In contrast with our expectation, the Agile Frog tadpoles reached metamorphosis in almost all ponds with fish. Such results would be more appropriate

for the Common Toad whose tadpoles produce toxins that deter predator fish (Giacoma, 1998). The expected positive correlation with the occurrence of wood in the ponds' surroundings reported by Pavignano *et al.* (1990) was not found in the present study. Despite its adaptability, the Agile Frog is a threatened species in some parts of Europe (Bressi & Stoch, 1999).

Chemical and physical parameters (*e.g.* oxygen concentration, pH, and water conductivity) were not included in this analysis due to the fieldwork and material restrictions. Other authors (Beebee, 1985; Pavignano *et al.*, 1990) report that these special parameters do not affect the amphibian habitat choice in the extent environmental parameters do. Nevertheless, chemical and physical parameters should be included in the future analysis in order to be able to compare ponds in this regard as well. For a better comparability with results of various other studies, the future research should contain a higher number of water bodies, and terrestrial habitat features from a larger range around ponds should be considered. Moreover, the correlation between the species occurrence and environmental variables should be tested with multivariate discriminant analysis. To test whether both multivariate analyses (CCA and discriminant analysis) are comparable, the two analyses should be carried out with the same data sets.

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IZBIRA KALA PRI DVOŽIVKAH (AMPHIBIA) NA KRASU IN V SLOVENSKI ISTRI

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POVZETEK

V obdobju od marca do avgusta 1999 smo preučevali okoljske dejavnike in z njimi povezano pojavljanje dvoživk v 7 kalih v Slovenski Istri in 10 kalih na Krasu. Kale smo obiskovali enkrat tedensko. Z vzorčenjem po standardnih metodah za dvoživke smo ugotavljali različne vrste dvoživk. Pogoste vrste, ki so se v obravnavanih kalih tudi razmnoževale, so bile: robati pupek (Triturus vulgaris meridionalis), *veliki pupek* (Triturus carnifex), *navadna krastača* (Bufo bufo), *zelena rega* (Hyla arborea), *rosnica* (Rana dalmatina) *in vrste iz skupine zelenih žab* (R. esculenta complex). *Izbiro kala smo analizirali s kanonično korespondenčno analizo. V analizo smo vključili 6 vrst dvoživk in 14 okoljskih dejavnikov. Korelacije med vrstami, okoljskimi dejavniki in kali prikazuje razvrstitveni diagram. Najpomembnejši pri izbiri kala so bili dejavniki, ki opredeljujejo terestrični habitat v okolici kala, ter zaraščenost vodne površine v juliju. Eden izmed pomembnih dejavnikov so bile tudi ribe, ki imajo v kalih izrazito negativen vpliv na pojavljanje dvoživk. Pri izbiri kala so bile najbolj selektivne zelena rega in vrste iz skupine zelenih žab. Kot najmanj selektivne, zelo prilagodljive vrste pa diagram prikazuje obe vrsti pupkov in rosnico.*

Ključne besede: dvoživke, Amphibia, kal, okoljski dejavniki, kanonična korespondenčna analiza

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GENETSKE RAZISKAVE OLJKE

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IZVLEČEK

*Oljka (*Olea europaea *L.) že tisočletja uspeva v Sredozemskem bazenu, kjer je ena pomembnejših gojenih sadnih vrst. K vse večjemu povpraševanju in porabi oljčnega olja prispeva spoznanje, da je oljčno olje vir zdravih maščob v primerjavi z drugimi rastlinskimi maščobami, posledično pa narašča potreba po vzgoji in žlahtnjenju novih, sodobnih sort. V tem pogledu je vrednotenje obstoječih genskih virov oljke zelo pomembno, saj so le ti vir lastnosti, ki jih lahko izkoristimo v programih izboljšanja genetskega materiala oljke. V primerjavi z drugimi hortikulturnimi rastlinami, kjer je bil narejen velik napredek v vzgoji novih sort z uporabo molekulsko genetskega znanja, so raziskave te vrste pri oljki razmeroma skromne. V zadnjem času je zaslediti pomembne premike na tem področju. Namen prispevka je prikazati trenutno stanje genetskih preučevanj oljke po svetu, vključno z domačimi raziskavami.*

Ključne besede: oljka, *Olea europaea*, molekulski markerji, genetska raznolikost

STUDI GENETICI SUGLI OLIVI

SINTESI

*Da millenni l'olivo (*Olea europaea *L.) prospera nel bacino Mediterraneo, dove viene considerato uno degli alberi da frutta coltivati più importanti. I sempre maggiori richiesta e consumo dell'olio d'oliva sono dovuti alla conoscenza del fatto che tale olio contiene grassi benefici, a differenza di altri grassi vegetali. Di conseguenza cresce anche il bisogno di coltivare e nobilitare nuove sorte contemporanee. In questo contesto risulta molto importante la valorizzazione delle fonti genetiche esistenti, in quanto uniche fonti di caratteristiche che possono venir adoperate nei programmi di miglioramento del materiale genetico dell'olivo. In confronto ad altre piante orticulturali, per le quali è stato raggiunto un notevole progresso nella coltivazione di nuovi cultivar con l'aiuto della conoscenza genetica e molecolare, tali ricerche sono relativamente modeste per quanto riguarda l'olivo. Negli ultimi tempi si sono però registrati importanti passi avanti in questo campo e scopo dell'articolo è quello di illustrare la presente situazione nel campo della ricerca genetica dell'olivo nel mondo e nel campo di ricerca sloveno.*

Parole chiave: olivo, *Olea europaea*, marcatori molecolari, diversità genetica

UVOD

Glede na spoznanje, da je oskrba tradicionalnih nasadov ekonomsko neutemeljena, se pridelovalci že od sredine prejšnjega stoletja ukvarjajo z vprašanjem, kako povečati rodnost oljčnih nasadov in znižati stroške pridelovanja oljk. Vpeljava novih gojitvenih oblik v oljčnike je med prvimi ukrepi, ki so bistveno povečali hektarske pridelke oljk. Manjše sadilne razdalje so vplivale na povečanje gostote dreves na hektar in posledično tudi višino pridelka. Izboljšana prehrana dreves z makro- in mikrohranili je pripomogla k rednejši in boljši rodnosti. Z namakanjem oljk so se pridelki povečali za 40 do 70%. Izbira ustreznih sort, prilagojenih intenzivni pridelavi, pa ostaja med pomembnejšimi dejavniki, ki vplivajo ne samo na višino pridelka, temveč tudi na njegovo kakovost.

Poraba oljčnega olja iz leta v leto narašča, potrošniki so glede kakovosti vse bolj zahtevni, zato je večina raziskav usmerjena ravno v preučevanje lastnosti oljčnega olja. Dosedanje raziskave so pokazale, da so sortno značilne kemične in organoleptične lastnosti tiste, ki s tehniko predelave plodov vplivajo na končno kakovost oljčnega olja. V procesih izboljšanja rastlinskega materiala oljke so največja ovira pomanjkljivi in nezadovoljivi podatki vrednotenja sort ali natančneje agronomskih lastnosti sort in sortne značilnosti oljčnega olja. To je tudi najpomembnejši razlog, zakaj je sistematična preučitev obstoječih genskih virov oljke potrebna. Velika genetska raznolikost oljke se kaže v množici najrazličnejših sort, klonov in divjih populacij, med katerimi lahko odberemo genotipe z najprimernejšo kombinacijo genov za intenzivno gojenje. Z namenom preučevanja genetske raznolikosti oljke ter odkrivanja najprimernejših genotipov, ki bodo poleg dobre prilagojenosti tehnologijam intenzivnega oljkarstva zagotovili še kakovosten pridelek, so v različnih državah ustanovili kolekcijske nasade, v katerih so zbrane sorte z določenega območja. Primerjalna študija med standardnimi in prinešenimi sortami v kolekciji je najhitrejša in najprimernejša pot pri iskanju alternativ za nezadovoljivo sortno strukturo nekega pridelovalnega območja. V kolekcijskih nasadih poteka sistematično vrednotenje agronomsko zanimivih lastnosti in lastnosti oljčnega olja posameznih sort. Na osnovi večletnih opazovanj se ocenjuje genetski potencial dreves in izvrednoti vpliv okolja na določene lastnosti, kar je nujno pred začetkom uresničevanja programov izboljšanja rastlinskega materiala. Agronomske lastnosti, ki se vrednotijo v kolekcijah, so dolžina mladostnega obdobja, rodnost, bujnost dreves, čas cvetenja, odpornost na bolezni in škodljivce ter tolerantnost na stresne dejavnike, kot so suša, nizke temperature, slana tla, itd. Vsebnost olja v plodovih (oljevitost sorte) je skupaj z rodnostjo pomembnejši parameter ocene neke sorte. Teža plodu je precej odvisna od okolja, medtem ko je vsebnost olja, izražena v suhi snovi, zelo odvisna od posameznega genotipa oz. sorte. Kakovost olja posameznih sort v kolekcijah določajo z analitskimi in senzoričnimi analizami, ki v splošnem vključujejo sestavo in razmerje maščobnih kislin ter parametre stabilnosti olja. Pri tem se ocenjuje tako komercialna kot hranilna vrednost olja. O razlikah v sestavi maščobnih kislin med sortami poročajo številni avtorji. Minorne sestavine dajejo olju posebno vrednost, med njimi so najpomembnejši antioksidanti (biofenoli in tokoferoli). Razlike v sestavi teh komponent v oljih so posledica različnih ekstrakcijskih postopkov in vpliva sorte. Pri preučevanju minornih sestavin bi bilo treba določiti, v kolikšni meri na njihov nastanek vplivata genotip in okolje.

Kljub temu da je oljka genetsko bogata, oljkarji še nimajo na voljo sort, ki bi popolnoma ustrezale vsem zahtevam intenzivnega oljkarstva. Vzrok so skromnejši programi izboljšanja genetskega materiala oljke v preteklosti. Selekcija sort in klonska selekcija sta bili glavni dejavnosti, ki sta pripeljali do izboljšanja lastnosti obstoječih sort. Do sedaj je bilo v načrtovanih programih izboljšanja vzgojenih le nekaj sort. V Izraelu so z masovno selekcijo vzgojili sorti 'barnea' in 'kadesh', v Italiji so nove izboljšane sorte v fazi preizkušanja, v Španiji pa v programih izboljšanja ni bila vzgojena še nobena nova sorta (Rallo, 1999). Cilj klonske selekcije je med večjim številom osebkov neke sorte izbrati genetsko in zdravstveno najboljše. Klonska selekcija oljk se opravlja v različnih državah, o komercialni vrednosti klonov poročajo le v nekaj primerih. Tako so v Italiji zaščitili dva klona (FS-17 in DA-12) (Fontanazza, 1996). V Španiji so odbrali 52 klonov sorte 'manzanilla di Sevilla' in 15 klonov sorte 'arbequina', ki so v fazi primerjalnih analiz s standardi. Tudi v Turčiji poročajo o prvih rezultatih klonske selekcije avtohtonih sort, katerih kloni imajo boljše lastnosti v primerjavi s standardi (Fiorino & Rallo, 1999). Z genetskega stališča se slabost klonske selekcije kaže predvsem v zmanjševanju genetske raznolikosti, saj je gojenje omejeno le na določene genotipe.

Med pomembne strategije izboljšanja genetskega materiala oljke uvrščamo tudi križanja, katerih cilj je izboljšati kakovost plodov (povečanje oljevitosti, izboljšanje karakteristik plodov) in prilagojenost rastlin na intenzivne pridelovalne okoliščine ter stresne razmere. V Italiji so leta 1971 križali 17 različnih sort oljk, ki se uporabljajo za vlaganje in olje. Rezultati dolgoletnih opazovanj agronomskih lastnosti potomcev so pokazali, da lahko pri oljki s križanji vzgojimo nove, tržno zanimive sorte. Na Kitajskem so sistematična križanja sort oljk pričeli leta 1980 z namenom vzgoje novih sort, ki bodo bolje prilagojene na klimatske in talne razmere (Fontanazza, 1996). Z načrtovanimi križanji lahko izboljšamo splošne lastnosti sort, vnesemo pa tudi neželene gene, ki jih moramo s številnimi povratnimi križanji odstraniti. Majhen in počasnejši napredek pri vzgoji novih sort oljk s križanji v primerjavi z drugimi

rastlinskimi vrstami je zagotovo posledica izredno dolgega mladostnega obdobja oljke. Rezultati dosedanjih križanj oljk sicer odpirajo nove poti in možnosti k ustvarjanju tržno zanimivih sort, vendar pa so informacije o dedovanju pomembnih lastnosti še vedno omejene, saj so preučene le na nivoju fenotipa. Specifičnih raziskav glede povezave med genotipom in fenotipskimi lastnostmi ni na voljo, posledica tega pa so pomanjkljivi selekcijski kriteriji.

Pregled, ali t.i. inventarizacija obstoječih genskih virov oljke torej sodi med prioritetne dejavnosti intenzivnega oljkarstva, nam omogoča vpogled v genski bazen udomačene oljke in njene divje sorodnike, ki so lahko nosilci zanimivih in nadvse koristnih agronomskih lastnosti, kot so odpornost za bolezni, škodljivce in stres. Vse te lastnosti lahko uporabimo v programih izboljšanja genetskega meteriala oljke pri ustvarjanju novih sort.

Razvoj molekulskih metod je omogočil alternativne pristope v številnih genetskih raziskavah. Vsestranska uporabnost molekulskih markerjev omogoča hitrejše reševanje problemov, ki se pojavljajo pri žlahtnjenju rastlin, identifikaciji sort in klonov, ugotavljanju sorodstvenih odnosov med osebki, vrednotenju genetskega materiala in iskanju polimorfizma itd. Pri vzgoji novih sort s križanji lahko s pomočjo molekulskih markerjev identificiramo potomce z želenimi lastnostmi, saj je selekcijo sejancev mogoče opraviti že v mladostnem obdobju rastline, kar bistveno skrajša čas žlahtnjenja. Markerji so namreč v nekaterih primerih tesno vezani na gene, ki kontrolirajo agronomsko zanimive lastnosti, zato jih lahko uporabljamo za sledenje lastnosti po križanju. Pomembno mesto med genetskimi raziskavami z molekulskimi markerji imajo preučevanja genetske raznolikosti oljke in študije sortne strukture območij, kjer se uveljavlja zaščita geografskega porekla oljčnega olja. Sorodstveni odnosi med sortami omogočajo rešiti tudi nekatere domneve, kot je npr. avtohtonost sort. Poznavanje genetske variabilnosti oljke na nekem območju nam lahko zagotovi koristne informacije o selekciji, nastanku sort in geografskem izvoru. V zadnjem času je bilo veliko raziskav namenjenih tudi rekonstrukciji zgodovine udomačitve, izvoru in širjenju oljke.

Metode molekulske biologije so prispevale nekatere novosti tudi v diagostiki, pri ugotavljanju okuženosti rastlinskega materiala z virusi. Spremljanje zdravstvenega stanja sadik je pomembno pri vzgoji certificiranega materiala. Poleg klasičnih imunoloških testov ELISA za ugotavljanje virusov v rastlinah so na voljo tudi postopki, ki temeljijo na uporabi polimerazne verižne reakcije (PCR). Metode PCR omogočajo hitro in zanesljivo identifikacijo virusa. Molekulske metode za odkrivanje virusov oljke se že uporabljajo v Španiji in na Portugalskem (Rallo, 1999). Med pomembnejše raziskave sodijo tudi poskusi vzgoje oljk s tkivnimi kulturami. Mikropropagacija (razmnoževanje) *in vitro* je bistveno skrajšala čas razmnoževanja, ki je neodvisen od letnega časa, poleg tega pa omogoča vzgojo večjega števila rastlin na majhnem prostoru. Preliminarne rezultate vzgoje in razmnoževanja oljke *in vitro* so predstavili v Italiji (Standardi *et al.*, 1998; Leva *et al.*, 2000). Vzgoja odpornih sort na bolezni in škodljivce ter stresne razmere sodi med najpomembnejše cilje sodobnega kmetijstva. Razvoj genskega inženirstva je omogočil vnašanje genov v genom rastline z natančnim zapisom za določeno lastnost. S postopkom neposrednega vnašanja želenih genov premostimo težave, kakršna je npr. nekompatibilnost pri križanju dveh genetsko oddaljenih vrst, izognemo se vnosu neželenih lastnosti, itd. O prvem poskusu genetske transformacije oljke poročajo v Italiji (Mencuccini *et al.*, 1998). Rezultati so spodbudni in perspektivni. Oljko namreč pridelovalci želijo gojiti v širšem arealu, zato je treba vzgojiti sorte, ki bodo dobro prenašale sušo, težka tla in nizke temperature. Raziskave bodo v prihodnosti usmerjene v iskanje in identifikacijo genov za odpornost na biotski in abiotski stres. Zanimivi so tudi geni, ki so povezani s kakovostjo pridelka.

MOLEKULSKI MARKERJI V GENETSKIH ŠTUDIJAH

Rastline imajo tri avtonomne genome. V jedru celice je jedrna DNA, celična organela (plastida), kloroplast in mitohondrij, ki sta v celični citoplazmi, pa vsebujeta kloroplastno DNA (cpDNA) oz. mitohondrijsko DNA (mtDNA). Za plastidni DNA je značilno nemendlovsko ali citoplazmatsko dedovanje, kar pomeni, da se od jedrne DNA neodvisno dedujeta, večinoma po materi. Variabilnost v molekulskih markerjih in sekvencah nekaterih genov kloroplastnega genoma se uporablja za karakterizacijo rastlinskih populacij ali divjih sorodnikov (Javornik, 1996). Raznolikost mitohondrijskega genoma pri rastlinah je zanimiva za ugotavljanje pretoka genov in strukture populacije. Rastline z enako mtDNA imajo skupnega ženskega prednika, saj se pri dedovanju materina mtDNA prenese na vse potomce, zato lahko sledimo maternalnem rodovniku. Ker se ne rekombinira, se mutacije v njej akumulirajo hitreje, tako da je mtDNA bolj polimorfna v primerjavi z jedrno DNA.

Prvi markerji, ki so se uporabljali za vrednotenje raznolikosti pri rastlinah, so bili fenotipski (morfološki). Uporaba le-teh je bila povezana s številnimi metodološkimi težavami, kot so zamudno delo, omejeno število razpoložljivih markerjev, odvisnost markerjev od razvojne stopnje rastline in okolja ter subjektivni pristop pri vrednotenju. Razvoj in uporaba izoencimskih markerjev sta genetsko analizo vodila na molekulski nivo, vendar je bila zaradi majhne številčnosti njihova uporaba omejena. Razvoj molekulskih markerjev je omogočil revolucionaren pristop preučevanja genomov. Marker je lahko katerokoli zaporedje DNA, ki ga lahko brez večjih težav odkrijemo in spremljamo njegovo dedovanje. Danes imamo kar nekaj molekulskih markerjev, ki se

razlikujejo v svojih lastnostih, informativnosti, ceni razvoja markerskega sistema in zahtevnosti tehnike. Glede na namen preučevanja organizma lahko izbiramo med hibridizacijskimi (RFLP markerji) in PCR (RAPD, AFLP markerji, mikrosateliti) tehnikami.

Prvi razviti markerski sistem, ki je omogočil odkrivanje polimorfizma na nivoju DNA, so markerji RFLP (polimorfizem dolžin restrikcijskih fragmentov). Tehnologija RFLP temelji na razrezu genomske DNA z restrikcijskimi encimi, razrezani DNA fragmenti se nato elektroforetsko ločijo in prenesejo na membrano, sledi odkrivanje specifičnih fragmentov DNA s hibridizacijo z radioaktivno označeno sondo. Razlike med preučevanimi organizmi opazujemo kot spremenjene vzorce DNA restrikcijskih fragmentov. Pri študijah genetske raznolikosti organizmov se prednost tega markerskega sistema kaže v tem, da so rezultati dobro ponovljivi med različnimi laboratoriji, med slabosti pa lahko uvrstimo tehnično zahtevnost metode. Markerje RFLP so raziskovalci v oljkarstvu uporabili predvsem v študijah genetske raznolikosti kloroplastne in mitohondrijske DNA z namenom rekonstrukcije širjenja oljk v Sredozemlju, ugotavljanju izvora in sorodnosti divjih in kultiviranih oljk.

V zadnjih nekaj letih so bili markerji RAPD najpogosteje uporabljeni molekulski markerji za preučevanje genoma oljke. Naključno namnoženo polimorfno DNA (RAPD) so raziskovalci uporabili v obsežnih študijah genetske sorodnosti oljk glede na geografski izvor in uporabo plodov (Fabbri *et al.*, 1995; Claros *et al.*, 2000; Belaj *et al.*, 2001, 2002; Besnard *et al.*, 2001; Sanz-Cortés *et al.*, 2001) in identifikaciji sort (Vergari *et al.*, 1998; Wiesman *et al.*, 1998; Barranco *et al.*, 2000; Bandelj *et al.*, 2001). Markerji RAPD omogočajo odkrivanje in analizo polimorfizmov v celotnem genomu. Metoda temelji na namnoževanju neznanih predelov DNA. Razlike med analiziranimi osebki preučujemo s primerjavo DNA odtisa (profila) posameznega organizma. Velika prednost tehnike RAPD je v nizki razvojni ceni ter v njeni preprostosti, največji omejevalni dejavnik pa slaba ponovljivost rezultatov, kar preprečuje medlaboratorijsko primerjavo.

Markerji AFLP (dolžinski polimorfizem namnoženih fragmentov) ravno tako kot RAPD omogočajo odkrivanje polimorfizmov iz naključnih regij genoma. Ker pokrivajo večji del genoma, se pogosto uporabljajo v različnih genetskih raziskavah, kot so genotipiziranje DNA, identifikacija, kartiranje in preučevanje genetske sorodnosti (Vos *et al.*, 1995; Maughan *et al.*, 1996; Sharma *et al.*, 1996; Cervera *et al.*, 1998; Jakše *et al.*, 2001). Informacije o uporabnosti markerjev AFLP v genetskih raziskavah oljke so omejene, saj je bila objavljena le študija Angiollilo *et al.* (1999), v kateri so preučevali genetsko raznolikost znotraj in med populacijami rodu *Olea*.

Prvi mikrosatelitni markerji oljke so bili znani v letu 2000 (Rallo *et al.*, 2000; Sefc *et al.*, 2000). Informacije o karakterizaciji izoliranih mikrosatelitov oljke so za zdaj še precej omejene. Mikrosateliti združujejo lastnosti različnih markerjev, tako da jih v literaturi večkrat omenjajo kot idealen markerski sistem za genetske študije. Odlikujejo jih možnost odkrivanja visoke stopnje polimorfizma in s tem velika informativnost (Morgante & Olivieri, 1993; Powell *et al.*, 1996).

PREGLED GENETSKIH RAZISKAV OLJKE

Študije izvora in domestikacije oljke

Arheološke izkopanine dobro ohranjenih karboniziranih oljčnih koščic pričajo o izjemni starosti oljke. Ocenjujejo, da se je oljka skupaj z žiti, stročnicami in datljem pojavila v Palestini okrog 4000 let pred našim štetjem. V srednji in pozni bronasti dobi sta bila oljkarstvo in proizvodnja oljčnega olja dobro razvita na širšem območju Sredozemlja, od Palestine in Sirije do Grčije. Kasneje, v obdobju kolonizacije, so oljko z Bližnjega vzhoda zanesli še v druga sredozemska območja. Oljka pripada kompleksu *O. europaea* (Green & Wickens, 1989), ki je glede na morfološke karakteristike oljk sestavljen iz 6 podvrst. Vsaka podvrsta je značilna za določeno geografsko območje. *O. europaea* subsp. *europaea* je poznana kot sredozemska oljka, *O. e.* subsp. *maroccana* (Greut. & Burd.) je endemična na območju južnega Maroka, *O. e.* subsp. *laperrinei* (Batt. & Trab.) uspeva v Saharskem gorovju, *O. e.* subsp. *cerasiformis* (Webb & Berth.) je endemična na Madeira otoku, *O. e.* subsp. *guanchica* je poznana na Kanarskih otokih, *O. e.* subsp. *cuspidata* (Wall.) pa je razširjena v južni Afriki in na Kitajskem. Podvrsta *cuspidata* je sestavljena iz več morfološko različnih tipov, ki so omejeni z geografskim območjem: *Olea africana* Mill. (od južne do vzhodne Afrike), *O. chrysophylla* Lam. (od vzhodne Afrike do Arabije) in *O. cuspidata* Wall. (od Irana do Kitajske) (Besnard *et al.*, 2002).

Domestikacija v današnjo kultivirano sredozemsko oljko (*Olea europaea* L. subsp. *europaea* var. *europaea)* je potekala s selekcijo na večji plod in višjo vsebnost olja, spremenila je tudi reproduktivno biologijo drevesa. Kultivirane oljke se razmnožujejo nespolno (vegetativno) s kloni, tako da imajo fiksirane želene lastnosti. Divje oljke (oleastri) [*Olea europaea* L. subsp. *europaea* var. *sylvestris* (Mill.) Lehr] uvrščamo v dve skupini; divje oblike, ki uspevajo v primarnih nišah brez kultiviranja in sredozemskih gozdovih, ter podivjane tipe, ki so nastali s spontanim križanjem med oleastri in sortami v opuščenih nasadih (Zohary & Spiegel-Roy, 1975). Divjih (pravi oleastri) in podivjanih oblik (feral) na osnovi morfoloških znakov ni moč ločiti, ker so si fenotipsko izredno podobne, medtem ko so uspešno opravili identifikacijo oz. ločitev z molekulskimi markerji. Kultivirane, divje in podivjane oljke se lahko med seboj neovirano križajo. Križanja omogočajo vključitev genov

iz divjih oljk v kultivirane, kar se navsezadnje kaže v veliki genetski raznolikosti današnjih oljk. Kompleksno genetsko ozadje oljke je velik izziv za različne raziskovalne skupine, ki poskušajo pojasniti njihov nastanek, geografski izvor, genetsko sorodnost ter preučiti in rekonstruirati zgodovino udomačitve oljke.

Izvor in domestikacijo kultivirane oljke sta preučevala Besnard in Bervillé (2000). Z raziskavo sta želela ugotoviti, ali imajo kultivirane oljke in oleastri skupen izvor v sredozemskem bazenu, zato sta v analizo vključila oljke, razširjene v Aziji, Afriki in Evropi. Analizirala sta 121 sort, 300 oleastrov, 27 populacij iz sredozemskega bazena in 74 dreves različnih podvrst iz Maroka *(O. maroccana),* Alžirije *(O. laperrinei),* Kanarskih otokov *(O. e.* spp. *cerasiformis),* Kenije, Južnoafriške republike, Zimbabveja *(O. africana),* Jemna *(O. chrysophylla),* Irana, Indije in Kitajske *(O. cuspidata).* Z molekulskimi markerji sta preučevala raznolikost jedrne, mitohondrijske in kloroplastne DNA. Na osnovi rezultatov citoplazmatskega DNA polimorfizma sta naredila rekonstrukcijo širitve sort ter podala distribucijo tipov citoplazme v lokalnih oleastrih. Oljke *O. africana, O. chrysophylla* in *O. cuspidata* imajo različno kloroplastno DNA. *O. maroccana* in *O. e.* spp. *cerasiformis* imata tip kloroplasta, ki ga najdemo v večini sort in oleastrov. Več polimorfizma so odkrili v mitohondrijski DNA v primerjavi s kloroplastno DNA. V kompleksu *O. europaea* sta odkrila 12 različnih tipov mitohondrijske DNA (v nadaljevanju mitotip), vendar od teh le 4 take, ki obstajajo v sredozemskih oljkah. Oleastri in sorte vsebujejo mitotip ME1, kar nakazuje, da so današnje sorte nastale z domestikacijo oleastrov na Bližnjem vzhodu. Na zahodu se pojavlja mitotip MCK, ki pripada rodu *Olea* iz terciarne dobe. Mitotip MOM so odkrili v oljkah iz Sahare in vzhodne Afrike, ME2 pa samo v določenih sortah. Raznolikost jedrne DNA oleastrov, odkrite z markerji RAPD, je pokazala ločitev med vzhodnimi in zahodnimi oljkami, pri sortah pa ni bilo jasne meje, po vsej verjetnosti zaradi prenašanja rastlinskega materiala iz kraja v kraj in regionalne selekcije sort. V zaključkih sta avtorja zapisala, da obstaja več območij izvora in da je izvor oljke bistveno kompleksnejši, kot so pričakovali.

Študije genetske variabilnosti divjih in kultiviranih oljk

Med prve raziskave genetske variabilnosti oljke sodi delo Loukasa in Krimbasa (1983), ki sta analizirala 25 sort s petnajstimi izoencimski sistemi. Na osnovi raznolikosti izoencimskih sistemov sta ugotovila, da je velikost plodov oljk pomembna pri ugotavljanju sorodnostnih odnosov med sortami. Večjo genetsko sorodnost je možno odkriti pri sortah, ki so bile selekcionirane za namizne oljke (veliki plodovi). Podobno genetsko sorodnost sta odkrila tudi v skupini sort s srednje velikimi plodovi, ki se uporabljajo za olje.

V letu 1999 je bila objavljena prva obsežnejša študija genetske variabilnosti znotraj in med populacijami rodu *Olea* z markerji AFLP. Angiolillo *et al.* (1999) so z raziskavo želeli odgovoriti predvsem na dve vprašanji: iz katerih divjih oljk so se razvile današnje kultivirane oljke in katere populacije lahko v prihodnosti dodatno izboljšajo kultivirano oljko. V analizo so vključili 43 sort, 30 divjih oljk in 9 oljk, ki po klasifikaciji Greena in Wickensa (1989) ne pripadajo vrsti *O. europaea.* Obseg polimorfizma je pokazal zelo jasno ločitev kultiviranih in divjih oljk v dve skupini. Avtorji so poskušali odkriti povezavo med večjo genetsko sorodnostjo sort glede na geografski izvor, vendar so med sortami večjo genetsko sorodnost odkrili le pri oljkah s Sicilije. Slednje ugotovitve potrjujejo kompleksnost domestikacije oljke. Kultivirane in divje oljke ter vrste iz severnozahodne Afrike so genetsko sorodnejše v primerjavi z vrstami iz vzhodne Afrike in Azije. Največja variabilnost je bila odkrita pri vrstah z otokov Indijskega oceana in Avstralije. Avtorji so v nadaljevanju predvidevali, da sta kultivirana in divja oljka različni obliki iste vrste *O. europaea,* divji vrsti iz Maroka *(O. maroccana)* in iz Alžirije *(O. laperrinei)* pa sta verjetno vmesni obliki med *O. europaea* in azijskimi vrstami.

Amane *et al.* (1999) so z markerji RFLP preučevali polimorfizem kloroplastne DNA oljk iz sredozemskega bazena. Analizirali so 72 sort, 89 lokalnih, starih dreves in 101 oleastrov. Z analizo potomcev kontroliranega križanja so dokazali dedovanje kloroplastne DNA po materi. V celotni vrsti *europaea* so odkrili 5 različnih klorotipov. Klorotip I je bil najpogostejši v oleastrih in kultivirani oljki, drugi klorotipi (II, III in IV) pa so bili odkriti samo v oleastrih. Klorotip V so okarakterizirali s tremi mutacijami, ki jih najdemo v različnih predelih kloroplastne DNA (cpDNA), pojavil pa se je tako v kultiviranih kot divjih oljkah, vendar le v moško sterilnih drevesih s specifično anomalijo peloda. Predvidevajo, da je klorotip V povezan z večjo plodnostjo, ki je navadno opažena pri moško sterilnih drevesih.

V Maroku so Amane *et al.* (2000) preučili polimorfizem markerjev RFLP kloroplastne DNA kultiviranih in divjih oljk. Z raziskavo so želeli ugotoviti sorodstvene odnose med kultiviranimi in divjimi oljkami v Maroku in med vrsto *O. europaea* ter endemično vrsto *O. laperrinei* subsp. *maroccana.* Odkrili so 4 klorotipe: klorotip I je prevladoval v kultivirani (100%) in divji oljki (74%), kar kaže na tesno sorodstvo po materi, klorotipa II in III pa sta bila ugotovljena le v divjih maroških oljkah. Izvirnost taksona *O. maroccana* naj bi dokazoval klorotip IV, saj se je pojavil le pri tej vrsti.

Besnard *et al.* (2001) so zbrali 102 genotipa iz različnih območij Sredozemlja ter z analizo polimorfizma jedrne in mitohondrijske DNA preučili sorodstvene povezave sort. V raziskavi so uporabili markerje RAPD in RFLP. Na osnovi multivariatne analize so izdelali dendrogram, v katerem so bile sorte

razdeljene v 22 skupin, ki so se ujemale tako z regijo gojenja kot z uporabo oljk (olje/namizne oljke). Iz dobljenih rezultatov so predpostavljali, da je selekcija sort potekala v različnih regijah kot rezultat kolonizacije v času rimske dobe in prenašanja rastlinskega materiala z vzhoda na zahod. Podobno so sklepali tudi iz polimorfizma mitohondrijske DNA. Mitotipa MOM in MCK so odkrili samo v zahodnih sortah, ME1 mitotip pa v sortah iz Francije. Ker je ME1 mitotip značilen tudi za oleastre z vzhoda, menijo, da francoske sorte izhajajo prav z vzhoda. Njihovi rezultati potrjujejo tudi domnevo, da je selekcija v zahodem genskem bazenu potekala predvsem v smeri izboljšanja oljevitosti oljk.

Preučevanje polimorfizma jedrne in mitohondrijske DNA ostaja med najpogostejšimi raziskavami domestikacije oljke. Bronzini de Caraffa *et al.* (2002) so z molekulskimi markerji RAPD in RFLP preučili polimorfizem jedrne in mitohondrijske DNA kultiviranih in divjih oljk na Korziki in Sardiniji. Korzika in Sardinija sta zanimiv genski bazen oljk, saj v tem območju uspeva veliko sort in oleastrov. Oleastre je možno odkriti tudi v gozdovih. Sorte so bile večinoma prinešene iz Italije, nekaj pa jih je nastalo z lokalno selekcijo. V opuščenih nasadih uspevajo podivjane oljke, križanci oleastrov in sort. Podivjane oljke so sicer fenotipsko podobne oleastrom, večjo genetsko sorodnost pa kažejo s sortami. Z raziskavo so želeli preučiti tudi vpliv vzhoda (Italije) in zahoda pri nastanku korziških in sardinijskih oljk. V analizo so vključili 32 sort in 99 oleastrov. Polimorfizem mitohondrijske DNA je ravno tako kot pri zgoraj navedenih študijah pokazal obstoj 4 mitotipov; ME1, ME2, ki sta značilna za vzhodne oljke, MOM in MCK, karakteristična za oljke iz zahodnega Sredozemskega bazena. Večina sort s Korzike in Sardinije ima vzhodni mitotip, kar potrjuje difuzijo sort z vzhoda proti zahodu. Na Korziki so odkrili dve skupini sort. Ena je v tesni sorodnosti z oleastri, druga pa je povezana z italijanskimi in sardinijskimi sortami.

Raziskave genetske variabilnosti oljk potekajo tudi v Avstraliji. V južno Avstralijo so od leta 1836 prinesli na stotine sort oljk. Navzkrižno opraševanje dreves v 160 let starih in opuščenih nasadih se kaže v nastanku podivjanih populacij dreves, ki uspevajo v vseh regijah in so ekološki problem zaradi konkuriranja z naravno vegetacijo. Zaradi slednjega so ponekod lokalne oblasti oljčno drevo proglasile kot plevel in ga poskušale zatreti. Z namenom, da bi preučili dinamiko širjenja podivjanih vrst oljk, so Mekuria *et al.* (2002) z markerji RAPD analizirali populacijo 45 dreves iz južne Avstralije. Na osnovi vizualnih opazovanj so drevesa razdelili v tri skupine: sorte, domnevne potomce nekontroliranih križanj sort in podivjane oljke. Med seboj so primerjali profile RAPD posameznih dreves. Znotraj posamezne skupine oljk so odkrili velik polimorfizem, pri primerjavi polimorfizma med skupinami pa ni bilo večjih odstopanj.

Belaj *et al.* (2002) so z markerji RAPD preučevali genetsko raznolikost večje skupine sort (103) iz genske banke v Cordobi. Med glavne cilje raziskave so uvrstili: opisati raznolikost sort v svetovni genski banki oljke z markerji RAPD, izvrednotiti sorodnost med sortami znotraj kolekcije, preučiti vzorec raznolikosti sort z različnim geografskim poreklom, uporabiti dobljene informacije v žlahtniteljskih programih ter podati strategijo vzorčenja v kolekcijah genskih virov oljke. Združevanje v sorodnostne skupine sort iz sosednjih geografskih območij nakazuje, da imajo le te skupno genetsko ozadje. Veliko genetsko sorodnost kažejo francoske sorte in sorte iz vzhodnega in osrednjega Sredozemlja, kar pomeni, da imajo skupen izvor.

Molekulska karakterizacija in identifikacija kultivarjev oljk

Vegetativo razmnoževanje oljke je v preteklosti omogočilo intenzivno izmenjavo rastlinskega materiala v državah Sredozemlja, kar pa je povzročilo nejasnosti glede imenovanja sort in klonov. Številne in zelo različne sorte so nastale kot rezultat naravne selekcije ter selekcije sort in klonov na regionalnem nivoju. Število sort oljke je danes ocenjeno na 2000, vendar je lahko zaradi pojavljanja homonimov in sinonimov precenjeno ali podcenjeno, kar pa povzroča večje težave pri vrednotenju genetskega materiala oljke. Mnoge sorte so bile opisane že v davni preteklosti, veliko pa je takih, ki so še vedno neklasificirane ali celo neznane (Fontanazza, 1996). Na območjih, kjer je oljkarstvo tradicionalno in ni bilo večjih tehnoloških napredkov, lahko še danes najdemo ekotipe, ki so poznani le na lokalnem nivoju. Z namenom, da ohranijo genske vire oljke, so leta 1971 v Cordobi (Španija) ustanovili svetovno gensko banko oljke Olive World Germplasm Bank (OWGB). V genski banki je zbrano 328 sort iz različnih držav. Identifikacijska dela so pokazala, da je kar nekaj zbranih sort zastopanih večkrat, kar pa je posledica sinonimov (Caballero & del Rio, 1999). Zaradi boljšega kontroliranja rastlinskega materiala oljke v prometu in pravilne identifikacije sadik v drevesnicah moramo vzpostaviti sistem nedvoumne identifikacije sort in klonov, kar bo prispevalo tudi k hitrejšemu reševanju sinonimov in homonimov.

Prvi sistemi identifikacije oljk so temeljili na opisnih lastnostih rastline: vejice, socvetja, ploda, lista in endokarpa (Cifferri *et al.*, 1942). Primarno identifikacijo so v sklopu mednarodnega projekta RESGEN-CT96/97, ki ga financirata EU in Mednarodni svet za oljčno olje, začeli opravljati v 10 državah z namenom ohranitve, karakterizacije in zbiranja genskih virov oljke (Caballero & del Rio, 1999). Kvantitativni in kvalitativni deskriptorji oljke (Gregoriou, 1996; Cantini *et al.*, 1999; Levanič *et al.*, 2000; Koprivnjak & Pribetić, 2000) pa niso rešili dejanskega problema identifikacije, saj so ti znaki v

veliki meri odvisni od vplivov okolja, ekspresije genov, specifičnosti analiziranega tkiva in razvojnega obdobja rastline. Podobno velja tudi za izoencimske markerje, s katerimi so poskušali ločiti različne sorte v Španiji (Trujillo *et al.*, 1995) in Maroku (Ouazzani *et al.*, 1996). Z razvojem molekulskih markerjev se je sistem identifikacije bistveno spremenil. Tradicionalno vrednotenje in identifikacijo na osnovi morfoloških markerjev bi bilo smiselno dopolniti z molekulskimi markerji, saj nam bodo le slednji dokončno omogočili rešiti probleme imenovanja sort.

Markerji RAPD so bili do sedaj najpogosteje uporabljeni pri razločevanju sort. V Španiji so Belaj *et al.* (2001) proučevali polimorfizem in sposobnost razločevanja sort oljk iz genske banke v Cordobi. Analizirali so 51 reprezentativnih sort. Avtorji poročajo o markerskem sistemu RAPD kot zelo uporabnem pri upravljanju genskih bank, saj omogoča natančno in hitro identifikacijo večjega števila sort. Na osnovi multivariatne analize so izdelali dendrogram, v katerem so bile sorte razvrščene v sorodnostne skupine glede na geografski izvor.

Za provinco Malaga (Andaluzija) v južni Španiji so značilna območja, ki se močno razlikujejo v pedoklimatskih razmerah. Claros *et al.* (2000) so predpostavljali, da je v tem območju genetska variabilnost oljk kot posledica adaptacij na okoljske razmere zelo velika. Zaradi izjemne ekonomske pomembnosti oljke v Andaluziji in zaradi nepoznavanja genetskega ozadja tamkajšnjih oljk so analizirali 56 sort iz različnih oljčnikov. Pri ugotavljanju genetske sorodnosti s pomočjo markerjev RAPD so odkrili 3 skupine, med katerimi je ena vključevala avtohtone andaluzijske oljke, kar nakazuje, da so le-te nastale v območju s selekcijo in imajo skupno genetsko ozadje.

V Argentini uspevajo številne sorte španskega in italijanskega izvora. Cavagnaro *et al.* (2001) so pričakovali, da obstaja možnost napačnih imenovanj sort, zato so preučili 10 najpogostejših sort v Argentini, ki jih hranijo v zbirki v Mendozi. V analizo RAPD so vključili tudi nekatere istoimenske sorte iz genske banke v Cordobi. Pri primerjavi profilov RAPD sedmih sort iz svetovne kolekcije in kolekcije iz Argentine so odkrili, da ima le sorta 'manzanilla de Carmona' enak profil RAPD, vse druge pa se v profilu RAPD razlikujejo ('farga', 'empeltre', 'frantoio', 'manzanilla espanola', 'arbequina', 'arauco'). Največ razlik v profilih RAPD so odkrili pri sortah 'frantoio' in 'farga'. Razlike v profilih RAPD istoimenskih sort so lahko posledica napačnega poimenovanja ali pa obstoja različnih klonov znotraj sort.

Zaradi negotovosti glede identifikacije ter opaženih fenotipskih razlik znotraj nekaterih lokalnih sort so Wiesman *et al.* (1998) v Izraelu z markerji RAPD ovrednotili tradicionalne in prinešene sorte. Ugotovili so, da so slednje genetsko homogene. Lokalna sorta 'souri' je prav tako homogena in dobro definirana sorta. Znotraj sorte 'nabali' so odkrili polimorfizem, kar je verjetno posledica spontanih križanj različnih genotipov v preteklosti. Molekulska karakterizacija je raziskovalcem omogočila pojasniti, kako in kje se je lokalni material razmnoževal ter širil med pridelovalci v Izraelu.

V Franciji poteka revitalizacijski program oljkarstva, katerega namen je narediti podatkovno bazo petdesetih referenčnih genotipov oljk, ki bo v pomoč drevesničarjem pri identifikaciji in certifikaciji sadilnega materiala. Khadari *et al.* (2001) so z markerji RAPD opisali 32 sort. Da bi dobili res pravi referenčni profil sorte, so za vsako sorto analizirali najmanj 3 drevesa iz različnih lokacij. Pri 32 sortah so odkrili sortno specifičen profil RAPD, 2 do 3 različne profile RAPD na sorto pa so odkrili pri 9 sortah, zato so kot referenčni profil za identifikacijo avtorji izbrali tistega, ki je bil značilen za večino dreves analizirane sorte. Razlike v profilih RAPD znotraj sorte pripisujejo napačnemu poimenovanju in označevanju dreves. Pri analizi različnih klonov znotraj sort 'grossane' (13), 'cailletier' (6) in 'picholine' (8) z markerji RAPD niso odkrili razlik. Vsi kloni so imeli enak profil RAPD. Podatkovno bazo referenčnih genotipov oljk bodo v Franciji dopolnili še z mikrosatelitnimi markerji.

V Sloveniji se je v zadnjih štiridesetih letih sortna struktura precej spremenila, predvsem zaradi precepljanja starih lokalnih sort s sorto 'istrska belica' in sajenja sort, prinešenih iz Italije. Zaradi pomanjkljivih informacij o sortni strukturi območja slovenske Istre smo v letu 1999 pričeli z inventarizacijo sort s pomočjo mednarodnih deskriptorjev (Levanič *et al.*, 2000). Morfološko karakterizacijo smo v nadaljevanju dopolnili z molekulsko. Polimorfizem 10 prinešenih in 5 lokalnih sort oljk, ki uspevajo v kolekcijskem nasadu, smo preučili z markerji RAPD (Bandelj *et al.*, 2001). Glede na nivo odkritega polimorfizma lahko sklepamo, da imamo v Sloveniji veliko genetsko raznolikost sort, kar je pričakovati glede na število sort, prinešenih iz tujine. Razvili smo sistem identifikacije sort z markerji RAPD ter izdelali podatkovno bazo referenčnih sortnih profilov RAPD. Molekulska analiza dreves v kolekciji je potrdila identičnost genotipov znotraj trinajstih sort, pri dveh sortah pa smo odkrili napačno označitev dreves, do katere je po vsej verjetnosti prišlo v času dosajevanja. Markerji RAPD so uporabni pri upravljanju kolekcij, saj nam omogočajo preverjanje identitete sadik in s tem zmanjšanje napak pri postavitvi nasadov ali kolekcij.

Mikrosatelitni markerji in njihova uporaba v oljkarstvu

V letu 2000 sta dve raziskovalni skupini poročali o izolaciji prvih mikrosatelitnih markerjev oljke. Sefc *et al.* (2000) so objavili identifikacijo 15 mikrosatelitnih lokusov in predstavili njihovo karakterizacijo v izbranem setu oljk. Rallo *et al.* (2000) so izolirali 5 novih mikrosatelitnih markerjev oljke, preučili njihovo dedovanje na križancih družine 'leccino' in 'dolce agogia' ter jih uporabili v identifikacijske namene. Velika informa-

tivnost mikrosatelitnih markerjev je omogočila razločevanje med 42 sortami od 46 analiziranih. Cipriani *et al.* (2002) ter Carriero *et al.* (2002) so objavili najnovejša dela o postopkih izolacije mikrosatelitnih markerjev oljke. Med vsemi danes razpoložljivimi markerji mikrosateliti največ obetajo. Prednost tega markerskega sistema je v dobri ponovljivosti rezultatov znotraj in med laboratoriji ter možnosti izmenjave rezultatov med različnimi raziskovalnimi skupinami. Med slabosti uvrščamo visoko razvojno ceno tehnike ter dolgotrajen in zahteven postopek izolacije mikrosatelitov. V zadnjih dveh letih je razvoj mikrosatelitnih markerjev oljke že omogočil nekaj aplikativnih raziskav, ki jih bomo v nadaljevanju na kratko predstavili.

V okolici Gardskega jezera obstajajo 3 geografsko zaščitena porekla oljčnega olja: Garda Bresciano, Garda Orientale in Garda Trentino. Za vsako območje je natančno določeno, katero sorto lahko pridelovalci gojijo v oljčnikih in kolikšna količina določene sorte, izražena v odstotkih, sme biti zastopana v oljčnem olju. Zato je pomembno, da se sortna struktura preuči, preden se zakonsko določi, katera sorta sme biti v oljčnem olju določenega geografskega porekla in katera ne. Nekatera olja, ki so zaščitena z geografskim poreklom, smejo biti pridelana le iz avtohtonih ali lokalnih sort, medtem ko so lahko prinešene sorte v olju zastopane v zelo majhnem deležu. Sorta 'casaliva' naj bi bila lokalna in značilna za Gardo, vendar fenotipsko spominja na sorto 'frantoio', podobno velja za sorti 'les' in 'leccino'. Zaradi nejasnosti, ali gre za popolnoma različne sorte ali sorte s sinonimi, so Testolin *et al.* (2000) z mikrosatelitnimi markerji opisali 8 lokalnih sort ('casaliva', 'favarol', 'fort', 'grignan', 'les', 'raza', 'rossanel', 'trep') ter nekaj širše razširjenih italijanskih sort 'coratina', 'frantoio', 'leccino', 'maurino' in 'pendolino'. Opis DNA sort z mikrosatelitnimi markerji (genotipiziranje DNA) je pokazal, da imajo rastline iste sorte, ki uspevajo v različnih oljčnikih, večinoma enak genotip. Razlike, ki so jih odkrili znotraj nekaterih sort, pripisujejo akumuliranju mutacij v daljšem časovnem obdobju. Na osnovi primerjave genotipov sorte 'casaliva' in 'frantoio' menijo, da 'casaliva' pripada sortni populaciji 'frantoio', vendar gre za dve različni sorti. Enako velja tudi za sorti 'leccino' in 'les'.

Sorta 'oblonga' izvira iz Kalifornije (Corning), kjer so jo kot spontani sejanec odkrili okrog leta 1940. Glavna lastnost sorte je dobra odpornost proti *Verticillium dahliae*. Iz Kalifornije so jo prinesli v gensko banko v Cordobi. 'Frantoio' je znana kot pomembnejša sorta v osrednji Italiji, kjer jo gojijo že več sto let. Zaradi izredne kakovosti oljčnega olja je bila prenešena v številne države, vključno z Argentino, Južnoafriško republiko, Avstralijo in ZDA. V genski banki so odkrili, da sta sorti 'oblonga' in 'frantoio' fenotipsko identični, zato so preučili njune morfološke, agronomske lastnosti ter primerjali njuno DNA z mikrosatelitnimi markerji in markerji RAPD. Sorti 'oblonga' in 'frantoio' imata enake profile RAPD, enake alele na vseh mikrosatelitnih lokusih, razlik niso odkrili tudi pri primerjavi 15 morfoloških znakov (list, plod, endokarp) in 8 agronomskih lastnosti. Na osnovi molekulskih in morfoloških analiz avtorji domnevajo, da gre za isto sorto (Barranco *et al.*, 2000).

V Sloveniji smo s predhodno izoliranimi mikrosatelitnimi markerji (Sefc *et al.*, 2000) natančneje preučili 19 sort iz kolekcijskega nasada. Visoka informativnost mikrosatelitov je omogočila razločevanje med vsemi analiziranimi sortami. Pri primerjanju posameznih genotipov sort smo odkrili določeno podobnost med slovenskimi in toskanskimi sortami, kar lahko nakazuje, da so slovenske sorte z lokalno selekcijo na regionalni ravni nastale ravno iz italijanskih. Rezultati raziskave nam bodo omogočili identifikacijo sort, kontrolo izvora vegetativno razmnoženega rastlinskega materiala oljke in sadik ter pripomogli k boljšemu poznavanju in nastanku sortne strukture oljk v slovenski Istri. Predstavljeno opisovanje DNA sort z mikrosatelitnimi markerji je med prvimi tovrstnimi študijami na področju oljkarstva (Bandelj *et al.*, 2002).

GENETIC STUDIES IN OLIVES

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SUMMARY

The olive tree has been cultivated for millennia in the Mediterranean basin, where it happens to be one of the most important crops. The recognition of olive oil as a healthy source of fats in relation to other vegetable fats

increases its demand and consequently the need for more trait oriented breeding to develop new cultivars. In this respect, evaluation of olive germplasms has been recognized as very important, since collected germplasms can be a useful source of traits, not traditionally accounted for in olive selection in the past, but important for modern olive growing. In comparison to other horticultural plants with which significant improvements have been achieved using molecular genetic knowledge, relatively limited molecular research has been carried out in olives. Current genetic research and future orientations in relation to germplasm evaluation, genetic diversity studies and cultivar typing, including our own results, are discussed in this review.

Key words: olive, *Olea europaea*, molecular markers, genetic diversity

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THE USE OF THE FOG-SYSTEM IN THE OLIVE LEAFY CUTTING PROPAGATION

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ABSTRACT

The leafy cutting propagation of olive under mist is well known, although all so far carried out experiments have been based only on rooting results. The development of leafy cutting propagation method by woody plants has been made possible due to the development of the fog-systems in the last 15 years. Our experiment with the use of the fog-system in the propagation of 'Istrska belica' and 'Leccino' showed that the propagation of these olive cultivars in such a system is possible. The cuttings formed up to 7 main roots in the propagation season and their sprouts grew up to 20 cm.

Key words: olive, fog-system, leafy cutting propagation, rooting

L'USO DEL SISTEMA DI NEBULIZZAZIONE NELLA PROPAGAZIONE PER TALEA SEMILEGNOSA DELL'OLIVO

SINTESI

La propagazione dell'olivo tramite talea semilegnosa sotto nebulizzazione è ben nota, benché da tali esperimenti si siano avuti solamente risultati inerenti la radicazione. Negli ultimi 15 anni lo sviluppo del metodo della propagazione tramite talea frondosa con piante legnose è fortemente collegato alla nascita e allo sviluppo del sistema di nebulizzazione. Dagli esperimenti, nei quali è stato usato tale sistema nella propagazione delle specie Bianca Istriana e Leccino, risulta possibile la propagazione di questi cultivar di olivi con il sistema di nebulizzazione. Nella stagione della propagazione le talee hanno sviluppato fino a 7 radici principali e i loro germogli sono cresciuti fino a 20 centimetri.

Parole chiave: olivo, nebulizzazione, propagazione per talea semilegnosa, radicazione

INTRODUCTION

The olive propagation is carried out in the praxis mostly with leafy cuttings. In the praxis the cuttings are propagated on the moving tables under mist. As the cutting bases have to be heated during propagation period, the propagation costs are high. Using this system, the cultivars 'Istrska belica' and 'Leccino', which are the most important Slovenian cultivars, can be propagated relatively well, too.

The good experience with the use of the fog-system in the propagation of leafy cuttings with many woody plant species (and difficult-to-root species) in the last few years has enabled us to enhance the propagation success with the olive as well. As this method requires no heating of the cutting bases, it is much cheaper as the propagation in the mist system.

The effects of the slow release fertilizer, added to the rooting substrate, on the rooting and growth of cuttings were tested in the experiment.

In the past, many experiments with olive leafy cuttings under mist have been carried out. Rooting success depended strongly on the propagated cultivar. Vesel (1999) reported that the rooting results of the cv. 'Istrska belica' were about 60%, while the results with the cv. 'Leccino' were only about 30%. Contrary to such results are the farmers' findings: the rooting with the cv. 'Leccino' is better than with the cv. 'Istrska belica'. The outcomes of several experiments showed that the rooting success was only between 40% and 50% in various cultivars (Celik *et al.*, 1994; Fernandes-Serrano *et al.*, 2000). Celik *et al.* (1994) were able to reach better rooting results (up to 100%) by using a different type of tunnel in the cultivar 'Gemlik'. A very wide rooting range was also obtained by Özkaya and Celik (1994) who rooted cultivars 'Gemlik' and 'Domat' with rooting rates between 20 and 57% and in other treatments up to 100%.

All these experiments are based only on rooting results. Such experiments can be very problematic, as there are many other factors that can also dramatically affect rooting or propagation success (plant growth in the propagation season, over-wintering *etc.*). Spethmann (1997) suggested observing cutting experiments widely, not only through one parameter, such as rooting percentage. Many new experiments with numerous woody species showed several important advantages of the fog-system used in the cutting propagation. For the first time, very important plant arts could be economically rooted with the use of the fog-system: *Acer, Quercus, Hamamelis, Prunus* (Spethmann, 1986a, 1986b, 1997).

MATERIALS AND METHODS

The experiment was carried out in an unheated plastic house under a fog system in the experimental field of the Biotechnical Faculty in Ljubljana in 2001. Four levels (0, 0.2, 0.4 and 0.6g N/l substrate) of the slow release fertilizer "Osmocote-Plus 3-4M (15+11+11+2)" were tested with two olive cultivars 'Istrska belica' and 'Leccino'. The one-factor experiment with 4 replications and 30 cuttings per replication was carried out. The cuttings were cut at the end of June in a private orchard in Ankaran (Slovenia). Before being put in the rooting substrate (peat/sand in a 3:1 ratio), the cuttings were treated with 0.5% IBA (with 10% Euparen on talcum basis).

Data were collected in November 2001. The rooting results, the number and the length of the main roots and the sprout length were stated. The data were evaluated with ANOVA, the differences were tested with the Duncan-test at p=0.05.

RESULTS AND DISCUSSION

The rooting results of this first experiment with olive leafy cuttings in the fog system reached average values in both cultivars 'Istrska belica' and 'Leccino', namely up to 30%. The fertilizer variants showed highly varying results depending on the cultivars. In the case of 'Istrska belica', the best variant was the lowest fertilizer variant (0.2 g N/l), in 'Leccino' both the control variant and the strongest fertilizer variant (0.6 g N/l) gave the highest rate of rooted cuttings (Tab. 1).

Tab. 1: Rooting results regarding different fertilization variants of the substrate for two olive cultivars.
Tab. 1: Rezultati ukoreninjanja glede na fertilizacijske različice substrata za dva oljčna kultivarja.

Variant	Rooting (%)	
	'Istrska belica'	'Leccino'
Control	10.0	24.2
0.2 g N	30.9	7.8
0.4 g N	10.0	-
0.6 g N	5.0	23.4
$Duncan_{0.05}$	n.s.	-[a]

-[a]: statistical analysis was not possible/statistična analiza ni bila mogoča

These results cannot be accepted as positive when compared with the results of other difficult-to-root woody species propagated in the fog-system (Spethmann, 1986a, 1986b; Osterc & Spethmann, 2000). Anyway, it should be mentioned that some other experiments with olive leafy cuttings under mist, especially with 'Leccino', showed similar rooting results (Vesel, 1999). The control variant (without fertilizer) had no negative effects on the rooting process. This can be well explained with the fact that substrate fertilizing shows its effect on cutting growth later in the propagation season, when the roots have already been formed (Spethmann, 1997).

The number of the main roots was the greatest at the control variant in both olive cultivars, while the length of the roots was the greatest at the 0.2g N variant (Tab. 2, Fig. 1).

Fig. 1: Very well developed root system of olive cuttings cv. 'Istrska belica' at the end of the propagation season.
Sl. 1: Zelo dobro razvit koreninski sistem potaknjenca 'istrske belice' ob koncu razmnoževalne sezone.

Tab. 2: Number and length of the main roots regarding different fertilization variants of the substrate for two olive cultivars.
Tab. 2: Število in dolžina glavnih korenin glede na fertilizacijske različice substrata za dva oljčna kultivarja.

Variant	Number		Length (cm)	
	'Istrska belica'	'Leccino'	'Istrska belica'	'Leccino'
Control	5.4	5.3	14.7	13.6
0.2 g N	3.7	2.7	20.9	15.1
0.4 g N	4.0	-	9.7	-
0.6 g N	2.8	3.2	12.5	10.8
$Duncan_{0.05}$	n.s.	-[a]	n.s.	-[a]

-[a]: statistical analysis was not possible/statistična analiza ni bila mogoča

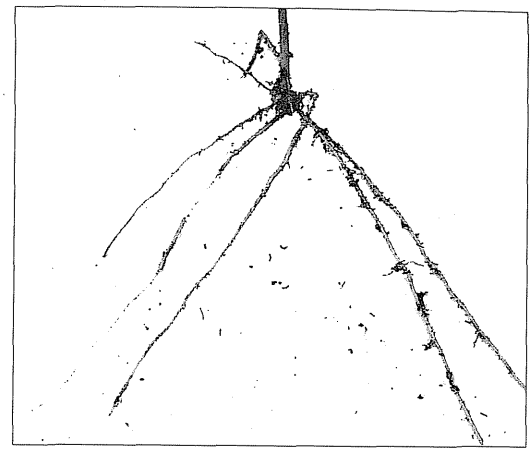

Fig. 2: Very well developed root system enables strong sprout growth of olive cuttings in the propagation season (cv. 'Istrska belica').
Sl. 2: Zelo dobro razvit koreninski sistem omogoča močno rast poganjkov oljčnih potaknjencev v razmnoževalni sezoni (cv. 'istrska belica').

It can be concluded yet again that substrate fertilizing showed its effect for first time when the rooting process had already been finished. The positive effect of the presence of the fertilizer can be seen in the phase of the root growth. This influence of the fertilizer has already been described several times in the case of many woody species in the new literature data (Spethmann, 1997; Osterc & Spethmann, 2000). But there is a lack of similar experiments with olive cuttings. There have been no literature reports in the last ten years on experiments with the olive leafy cuttings, which would include other rooting parameters beside rooting percentage as well (Celik *et al.*, 1994; Özkaya & Celik, 1994; Vesel, 1999).

The strongest growth of the main sprout can be observed with 7.0 cm at the 0.2 g N variant in 'Istrska belica' and with 5.4 cm at the control variant in 'Leccino' (Tab. 3, Fig. 2).

Tab. 3: Sprout growth of the cuttings regarding different fertilization variants of the substrate for two olive cultivars.
Tab. 3: Rast poganjkov potaknjencev glede na fertilizacijske različice substrata za dva oljčna kultivarja.

Variant	Sprout growth (cm)	
	'Istrska belica'	'Leccino'
Control	4.4	5.7
0.2 g N	7.1	3.0
0.4 g N	0.7	-
0.6 g N	1.5	3.5
$Duncan_{0.05}$	n.s.	-[a]

-[a]: statistical analysis was not possible/statistična analiza ni bila mogoča

The results with 'Istrska belica' confirm that the fertilizer in the substrate reacts in the propagation phase

when the rooting process has already been completed. The worse results with higher fertilizer concentration (0.6 g N variant) showed that higher N concentrations in the substrate could have negative effects on the cutting growth process. Such results were obtained also in the *Prunus*-cuttings (Osterc & Spethmann, 2000).

Although the propagation of olive leafy cuttings seems to be well developed, a number of experiments have shown relatively low rooting success, especially with some olive cultivars ('Leccino'). Additionally, many new experiments with several woody species in the last years have indicated a necessity to observe other propagation parameters as well, such as the number and the length of the main roots and sprout growth. The aim of our experiment was to optimise the method of the propagation of olive leafy cuttings. We used in our experiment the well-developed fog-system, and not only did the results deal with the rooting success but also with other parameters of the rooting and sprout growth. Some technical problems (insufficient fogging) caused relatively low rooting success on average, although some variants were more successful. However, it can be concluded that the new concepts in the propagation of leafy cuttings in various woody species (fog-system, time of cutting, over-wintering) can be successfully used also in the olive propagation process. The propagation method based on the fog-system does not require heating of the cutting bases, so the propagation costs are incomparably lower as in the mist system. The experiments should be continued to accurately determine and improve the steps of the process.

UPORABA SISTEMA MEGLENJA PRI RAZMNOŽEVANJU ZELENIH POTAKNJENCEV OLJKE

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POVZETEK

Proces razmnoževanja zelenih potaknjencev oljke s sistemom pršenja je dobro poznan. Vsi dosedanji rezultati temeljijo le na rezultatih koreninjenja. Razvoj metod razmnoževanja zelenih potaknjencev pri lesnatih rastlinah v zadnjih 15 letih je močno zaznamovan s pojavom in razvojem sistemov meglenja. Poskus razmnoževanja zelenih potaknjencev sort 'istrska belica' in 'leccino' z meglenjem je pokazal, da je takšno razmnoževanje možno. Rastline so v razmnoževalni sezoni razvile do 7 glavnih korenin ter pognale do 20 cm dolge poganjke.

Ključne besede: oljka, sistem meglenja, razmnoževanje zelenih potaknjencev, ukoreninjanje

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SEARCHING FOR BIOLOGICAL ACTIVITIES IN A NORTHERN ADRIATIC RED ALGA *POLYSIPHONIA* SP.

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ABSTRACT

Red alga Polysiphonia *sp. was tested for presence of hemolysins, antibiotics, acetylcholinesterase inhibitors and hemagglutinins. Although we found no activity in this organism, the screening procedure developed in our laboratory proved suitable for rapid detection of other potentially interesting bioactive molecules from different source material.*

Key words: natural marine products, red algae, *Polysiphonia*, antibacterial activity, hemagglutination, hemolysis, acetylcholinesterase

RICERCA DELLE ATTIVITÀ BIOLOGICHE NELL'ALGA ROSSA *POLYSIPHONIA* SP. DEL NORD ADRIATICO

SINTESI

L'alga rossa Polysiphonia *sp. è stata analizzata per la presenza di emolisine, antibiotici, inibitori dell'acetilcolinesterasi ed emagglutinine. Benché gli autori non abbiano trovato alcuna attività in tale organismo, le procedure di screening sviluppate nei loro laboratori si sono dimostrate appropriate per una identificazione rapida di altre molecole bioattive potenzialmente interessanti, provenienti da fonti diverse di materiale.*

Parole chiave: prodotti marini naturali, alghe rosse, *Polysiphonia*, attività antibatterica, emagglutinazione, emolisi, acetilcolinesterasi

INTRODUCTION

About 30% of the current worldwide human therapeutics derive from natural sources (Grabley & Thiericke, 1999). Recent trends in drug discovery emphasize investigation of the marine environment, which has already given some commercially known pharmaceuticals like Aracytine and Vidarabine from the sponge *Cryptotethya crypta*, or Ziconotide from the mollusc *Conus magus*. Marine organisms endow different defense strategies to survive in the highly competitive marine environment, thus resulting in a tremendous diversity of highly active compounds affecting numerous targets involved in eukaryotic cell signaling processes. However, toxic principles often dominate the spectrum of biologically active metabolites, hence in the last 20 years none of the isolated compounds have reached the pharmaceutical marketplace (Faulkner, 2000).

The aim of this study is to present a methodology that has been developed in our laboratory for fast screening of biologically active molecules in marine organisms. It is composed of a hemolytic, an antibacterial, a hemagglutination and an anticholinesterase test. A marine organism containing potential biologically active compounds usually has a clean surface, not fouled by other micro- or/and macroorganisms. Another indication of bioactivity may be the expansive growth of one species over the others during the territorial competition.

In 1996, a large quantity of algal complex with predominating red algae *Polysiphonia* spp. was noted in the sublittoral area of Cape Oštro (Northern Adriatic, Croatia; Fig. 1). Monitoring of its growth for a period of 1 year revealed that in the summertime, when the water temperature averaged about 23°C, the algal complex covered 80% of the area being observed (Arko-Pijevac, 2000), and dominated over different sessile marine organisms. A virtually black color of the sandy sediment surface at a depth of 12.5 to 15 m suggested the presence of anoxic conditions below the algal layer.

Red algae have been already reported to possess compounds exerting hemagglutinating (Hori *et al.*, 1987; Okamoto *et al.*, 1990), antibacterial (Mahasneh *et al.*, 1995; Etahiri *et al.*, 2001; Gao *et al.*, 2001), neurotoxic (Freitas *et al.*, 1995), mitogenic (Hori *et al.*, 1987), hemolytic (Freitas *et al.*, 1995; Igarashi *et al.*, 1998), antimutagenic (Okai *et al.*, 1996), ichthyotoxic (Igarashi *et al.*, 1998), antifungal and molluscicidal (Gao *et al.*, 2001), antimalarial (Etahiri *et al.*, 2001), antiviral (Carlucci *et al.*, 1997; Duarte *et al.*, 2001), anticoagulant (Carlucci *et al.*, 1997), cytotoxic and antialgal (König *et al.*, 1999), and fatty acid-oxidizing activity (Kajiwara *et al.*, 2000).

Fig. 1: A large quantity of algal complex with predominating red algae** Polysiphonia **spp. in the sublittoral area of Cape Oštro, covering 80% of the area. (Photo: M. Kovačić)
Sl. 1: Gosta prevleka alg s prevladujočimi vrstami iz rodu** Polysiphonia **v infralitoralu rta Oštro je prekrivala 80% obravnavanega območja. (Foto: M. Kovačić)

Concerning *Polysiphonia*, it has been shown that the extracts from some species of this genus are antiviral (Serkedjieva, 2000; Serkedjieva *et al.*, 2000), antibacterial (De Rosa *et al.*, 2001; Hellio *et al.*, 2001), antifungal and toxic to *Artemia salina* (De Rosa *et al.*, 2001). To examine if Northern Adriatic species of *Polysiphonia* contains certain biologically active compounds, leading to the observed overgrowth, we have tested its extracts using a developed methodology.

MATERIAL AND METHODS

Algal material

The *Polysiphonia* samples were collected at Cape Oštro (Northern Adriatic, Croatia) in 1998. They were kept at a temperature of -20°C until the start of the experiments.

Extraction procedure

Frozen algal tissue was lyophilized and powdered. Equal amounts (10 g each) of the obtained powder were suspended in eight different solvents (150 ml each) that would extract different substances contained in the plant according to the level of their polarity. The used solvents were water, methanol, absolute ethanol, acetone, 1-butanol, n-hexane, chloroform and aether-petrolei. Samples were shaken for 24 hours on the orbital shaker at 100 rpm and then filtered through a paper filter. The obtained filtrates were concentrated under reduced pressure. The dry weight of the concentrated extracts was determined by evaporating the solvent from 1 ml of the filtrate at 80°C.

Biological activity tests

For monitoring the possible presence of biologically active molecules in *Polysiphonia*, we tested different algal extracts for antibacterial, hemolytic, hemagglutinating and antiacetylcholinesterase activities. Pure solvents were used as controls for all tests.

Evaluation of antibacterial activity

For detecting possible antibacterial activities, a standard agar diffusion test was applied. Two Gram negative *(Shigella sonnei, Escherichia coli)* and two Gram positive *(Micrococcus luteus, Staphylococcus aureus)* bacterial strains were used. Bacteria were obtained from the bacterial collection at the Department of Biology, University of Ljubljana. They were allowed to grow overnight in Lauria Broth Base (Sigma, U.S.A.) and their concentrations were then determined. Bacterial cultures were incorporated into the agar-supplemented Lauria Broth that was cooled to 42°C beforehand. The final concentration of bacteria was approximately $5x10^5$ of colony-forming units per milliliter (CFU/ml). Twenty ml of inoculated medium were poured into Petri dishes and kept at a temperature of 4°C, then circles (Ø =1 cm) of agar were cut from the medium. Hundred µl of each extract or pure solvent were put into a circle of the Petri dish with different types of bacteria. The system was then kept overnight at 37°. Antibacterial activity was evaluated by measuring the diameter of inhibition zones.

Evaluation of hemolytic activity

Hemolysis was measured with a turbidimetric method according to Maček & Lebez (1981). Typically, 10-50 µl of different *Polysiphonia* extracts or pure solvents were added to a cuvette containing 3 ml of bovine erythrocyte suspension in 0.13 M NaCl, 0.02 M TRIS/HCl, pH 7.4, having an apparent absorbance of 0.5 at 700 nm. The decrease of apparent absorbance, deriving from hemolysis, was recorded using a UV/VIS spectrophotometer (Shimadzu 2100, Japan). The suspension in the cuvette was magnetically stirred. The experiment was performed at 25°C.

Evaluation of hemagglutination

Bovine erythrocytes were washed three times with 0.9% saline and twice with 0.14 M NaCl, 0.013 M TRIS/HCl, pH 7.4. Two-percent suspensions of washed erythrocytes were prepared in the same buffer, and pipetted onto microtiter plates (Nunc, Denmark). To the 100 µl of erythrocyte suspension in each well, 50-10 µl of different extracts or pure solvents were added. Following a 1-hr incubation at room temperature, hemagglutination was scored (Sepčić *et al.*, 1997).

Determination of acetylcholinesterase inhibition

The inhibition of acetylcholinesterase (AChE) was measured colorimetrically as described by Ellman *et al.* (1961). Briefly, to 3 ml of 0.1 M phosphate buffer, pH 8.0, 20 µl of 0.075 M acetylthiocholine iodide was added, followed by 100 µl of 0.1 M 5'-5'-dithiobisnitrobenzoic acid, and usually 10-100 µl of the sample to be tested (different extracts or pure solvents). After the absorption in reference and sample cuvettes had been auto-zeroed, the reaction was started by the addition of 20 µl AChE from electric eel (5 U/ml, Sigma, U.S.A.). The reaction was monitored for 10 minutes.

RESULTS AND DISCUSSION

Antibacterial test

Eight different extracts of red alga *Polysiphonia* sp.

were tested against 4 strains of bacteria and no extract showed antibacterial activity. All bacterial strains showed some growth inhibition by algal chloroform extract, which was proved as a solvent effect. The absence of antibacterial activity was somehow surprising, as different *Polysiphonia* species had already been reported to inhibit the bacterial growth. Organic extracts of two *Polysiphonia* species, a widely spread *P. denudata* and an endemic Black Sea species *P. denudata* f. *fragilis* showed considerable antibacterial activity against *Staphylococcus aureus* (De Rosa *et al.*, 2000). Hellio *et al.* (2001) have recently demonstrated that the antibacterial activity of marine algae is very selective. They tested 90 algal extracts against 35 strains of marine bacteria and found that only 18 extracts showed some activity. Among them, there was also an organic extract from *Polysiphonia lanosa*, exhibiting specific inhibitory activity against Gram positive marine bacteria.

Hemagglutination test

Compounds exerting hemagglutinating activities are usually glycoproteins and are therefore expected in water extracts. Although there are some reports on hemagglutination activities from marine red algae *Carpopeltis flabellata* (Hori *et al.*, 1987) and *Gracillaria bursa-pastoris* (Okamoto *et al.*, 1990), we did not detect any in our *Polysiphonia* extracts.

Hemolytic activity

The testing of *Polysiphonia* extracts did not reveal any presence of hemolytic substances. This is not surprising in view of very few reports of hemolytic activity of red algae (Freitas *et al.*, 1995; Igarashi *et al.*, 1998).

Acetylcholinesterase inhibition

In this study, we also report on the testing for acetylcholinesterase inhibition. If tested positive, it would indicate the presence of a neurotoxin. Although the test was negative, this is, as far as we know, the first attempt to detect AChE inhibition in red algae. A sole other example of a neurotoxic activity in red algae was found in *Liagora farinosa*, whose polar extract induced a dose-dependent inhibition of action potentials in the isolated crustacean nerve (Freitas *et al.*, 1995).

CONCLUSIONS

The results of this study suggest that the extracts from the *Polysiphonia* material collected in the Northern Adriatic do not possess biological activities that could be detected with the used tests. It is therefore possible that the observed overgrowth of this alga is due to some undetected activities, or rather to different environmental effects (light, turbidity, nutrients, temperature). It is also possible that the anoxic conditions below the algal layer had caused the mortality of other organisms living there, or had simply prevented them to settle there. Nevertheless, the presented screening procedure, consisting of four rather economical biological tests, can be further used for rapid (3-4 days) detection of other potentially interesting bioactive molecules deriving from different source material.

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RAZISKAVA BIOLOŠKIH AKTIVNOSTI V SEVERNOJADRANSKI RDEČI ALGI *POLYSIPHONIA* SP.

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POVZETEK

Morski organizmi so bogat vir strukturno še nepoznanih in biološko aktivnih molekul. V tej raziskavi so predstavljene nekatere metode za detekcijo takšnih spojin. Kot testni organizem je bila izbrana rdeča alga Polysiphonia *sp. Leta 1996 se je ta alga zelo razrasla v severnem Jadranu, kar bi lahko bil kazalec možnih prisotnih bioaktivnih spojin. Hemolitična, protibakterijska, hemaglutinacijska in protiholinesterazna aktivnost je bila testirana na različnih ekstraktih alge. Kljub temu da nobena od teh aktivnosti ni bila zaznana v preučevani algi, so se uporabljene metode pokazale kot uporabne za hitro določitev potencialno zanimivih bioloških molekul iz različnih virov. Še več, protiholinesterazni test je bil v tej raziskavi prvič uporabljen na rdečih algah.*

Ključne besede: naravni produkti iz morskih organizmov, rdeče alge, *Polysiphonia*, protibakterijska aktivnost, hemaglutinacija, hemoliza, acetilholinesteraza

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DELO NAŠIH ZAVODOV IN DRUŠTEV

ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ

ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

OCENE IN POROČILA

RECENSIONI E RELAZIONI

REVIEWS AND REPORTS

DELO NAŠIH ZAVODOV IN DRUŠTEV
ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ
ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

Boris Kryštufek & Mitja Kaligarič

INŠTITUT ZA BIODIVERZITETNE ŠTUDIJE ZRS Koper

Inštitut za biodiverzitetne študije (IBŠ) je bil ustanovljen leta 2001, tako da obstaja komaj dve leti. Z njegovo ustanovitvijo smo dosegli večjo prepoznavnost biodiverzitetnih in ekoloških raziskav, ki imajo na Znanstveno raziskovalnem središču RS Koper sicer že daljšo tradicijo. Nova organizacijska oblika omogoča boljšo organiziranost in učinkovitost biodiverzitetnih raziskav.

Pojem biodiverzitete se je iz učbenikov in predavalnic preselil v besedišče politike in popularnega tiska, osvojili pa so ga tudi ljudje na visokih položajih, ki odločajo, kaj se bo v prostoru dejansko zgodilo. To je seveda dobro, prinaša pa tudi nevarnosti zlorabe tega pojma. Še posebej zato je pomembno, da nad biodiverzitetnimi raziskavami in odločitvami v prostoru, ki so s tem povezane, bdijo strokovnjaki – biologi, ki jim ta pojem ni znan od včeraj.

Biodiverzitetna kriza svetovne razsežnosti danes na splošno velja za eno glavnih groženj nadaljnjemu obstoju človeške civilizacije na Zemlji. Globalna erozija biodiverzitete tako narekuje potrebo po novi varstveni (ohranitveni) teoriji, z izvirnimi konceptualnimi in empiričnimi rešitvami. Kljub hitremu razvoju v zadnjih desetletjih na področjih ekologije, biogeografije, taksonomije, paleontologije in evolucijske biologije, pa so procesi, ki generirajo biodiverziteto na najrazličnejših nivojih, še zmeraj slabo znani. Poleg tega se vse jasneje zavedamo, da odgovori na številne biodiverzitetne probleme presegajo tradicionalne znanstvene discipline. Če nič drugega, je treba tradicionalno "mikroskopsko" ekosistemsko analizo nadgraditi z makroekološkim pristopom. Klasično varstvo narave je pretirano usmerjeno k ohranjanju biodiverzitete s pomočjo zakonskega varstva vrst in prek rezervatnega varstva. Dejansko pa je ohranjanje stanja ekosistema lahko samo prehodna, kratkoročna rešitev. V dolgoročni perspektivi moramo poznati procese, ki generirajo biodiverziteto.

Pomembni so obseg, količina in vrsta motenj ter odziv biodiverzitete nanje. Zato so pomembne tudi širše ekološke raziskave, včasih meritve mikro-območij, včasih pa tudi sintezne biogeografske študije, da pridemo do želenih rezultatov.

Biodiverziteta obsega širok spekter strukturnih in procesnih elementov ter nivojev, ki odsevajo in vzdržujejo raznolikost živega sveta. Zaradi njene kompleksnosti jo navadno razstavimo na posamezne strukturne enote, ki izhajajo iz hierarhične organizacije življenja. Ta koncept je izhodišče organiziranosti temeljne raziskovalne dejavnosti na IBŠ:

a) Vrstna diverziteta

Biodiverziteto najlaže prepoznamo na vrstnem nivoju. Pomanjkanje ekspertov taksonomov je neredko glavni dejavnik, ki otežuje dokumentiranje biodiverzitetnih vzorcev. Vsak raziskovalec na IBŠ je zato izvedenec taksonom/favnist/florist za določeno skupino. Poseben poudarek je na ključnih, indikatorskih, krovnih in ranljivih taksonih. Trenutno pokrivamo sledeča področja: sesalci (B. Kryštufek), ptice (A. Sovinc) in višje rastline s praprotnicami (M. Kaligarič, S. Škornik).

b) Genetska diverziteta

Zaradi hitrega razvoja molekularne biologije na eni strani in izjemnega pomena genetske variabilnosti za varstvo viabilnih populacij je to področje zelo obetavno. IBŠ za zdaj za to področje nima usposobljenih kadrov.

c) Ekosistemska diverziteta

IBŠ vidi ekosisteme kot dinamične in odprte sisteme, brez njim lastnega ravnotežnostnega stanja. Zato ga stanja zanimajo samo kot izseki, ki omogočajo prepoznavanje procesov. V okviru tega vidika nas zanimajo struktura ekosistema, njegova "naravnost" in dinamika. Še posebej dinamiki se posveča skupina botanikov-ekologov (Kaligarič, Škornik, sodelavci z Univerze na Dunaju), saj je ta v nekaterih sekundarnih ekosistemih po spremembi rabe zelo velika.

d) Izobraževanje in posredovanje znanja

IBŠ posreduje javnosti rezultate teoretičnega študija in lastnih raziskav. To dosegamo prek publicistične dejavnosti in v obliki predavanj na vseh nivojih, vključno z visokošolskim.

Sodelavci IBŠ aktivno sodelujemo pri uresničevanju dodiplomskega in podiplomskega študija na univerzah v Ljubljani in Mariboru ter novogoriški Politehniki.

IBŠ ima kapacitete za posredovanje znanja in rešitev naravovarstveni operativi (priprava seznamov ogroženih vrst in akcijskih načrtov za njihovo ohranjanje, identifikacija vrst, svetovanje pri posegih v prostor). B. Kryštufek je član šestih specialističnih skupin za ohranjanje vrst pri Mednarodni zvezi za varstvo narave (Species Survival Commission, International Union for the Conservation of Nature), strokovni vodja delovne skupine "Varstvo živalskih vrst in *ex situ* varstveni ukrepi v žival-

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skih vrtovih" pri Sekretariatu za uresničevanje Konvencije o biotski raznovrstnosti (Ministrstvo za okolje, prostor in energijo), član Odbora za povezovanje R Slovenije v Globalno informacijsko mrežo za področje biotske raznovrstnosti, koordinator za vretenčarje pri projektu Biodiverziteta Slovenije (Ministrstvo za okolje, prostor in energijo), član medresorske Strokovne komisije za divjad pri Ministrstvu za kmetijstvo, gozdarstvo in prehrano ter član Komisije za veliko divjad pri Lovski zvezi Slovenije. Na sestanku BD Global Biodiversity Facilities (Pariz 11.-12. septembra) je bil vodja slovenske delegacije. M. Kaligarič je strokovni koordinator za sklop "Travišča" pri Sekretariatu za uresničevanje Konvencije o biotski raznovrstnosti (Ministrstvo za okolje, prostor in energijo), član sveta Krajinskega parka Sečoveljske soline in Naravnega rezervata Škocjanski zatok, recenzent znanstvenih projektov na Ministrstvu za šolstvo, znanost in šport (polje 16 – Biologija). Andrej Sovinc se je specializiral za področje ekološkega restavriranja, ki obsega restavriranje, rehabilitacijo in nadomestitev izgubljenih oz. degradiranih habitatov. Bojana Lipej je usposobljena za nekatere okoljske parametre in posege, predvsem z varovanjem obalnega morja pred onesnaženjem.

V teku svojega obstoja je bil IBŠ aktiven na več področjih. Najbolj odmevna je bila raziskovalna delavnica "Vzorci in procesi v biodiverziteti Balkana", ki je potekala v času od 25. do 28. septembra 2001 v organizaciji ZRS RS Koper in Univerze Hull (UK) v Kopru. O njej smo v Analih že govorili, saj so bili natisnjeni tudi izvlečki (23/'2001, seria historia naturalis 11 (suplement): 1-18). Programski in organizacijski odbor (doc. dr. Darko Darovec, prof. dr. Boris Kryštufek, dr. Huw I. Griffiths (✞), doc. dr. Lovrenc Lipej) je povabil 23 raziskovalcev iz Slovenije, Hrvaške, ZR Jugoslavije, Bolgarije, Grčije, Nemčije, Češke, Ukrajine in Velike Britanije.

Osnovni razlog za organizacijo srečanja je bila potreba po tesnejšem povezovanju raziskovalcev, ki preučujejo balkansko biodiverziteto. Balkanski polotok je namreč eno glavnih žarišč evropske biodiverzitete, kar je vsaj deloma odsev geološke zgodovine, velikega števila endemitov, pomena polotoka kot ledenodobnega zatočišča in njegove vloge pri izmenjavi elementov z Malo Azijo. Delo je potekalo v petih tematskih sklopih: (1) izvor in starost elementov v balkanski favni, (2) prispevek balkanskega refugija h genomu severne Evrope, (3) evolucijski prispevek balkansko-anatolskega mostu, (4) varstveni status "vročih točk" in "zbiralnikov", ter (5) paleoklima, paleovegetacija in teorija speciacije.

Raziskovalni projekti

V letu 2001 smo pridobili temeljni raziskovalni projekt *"Biodiverzitetni vzorci in procesi"*, ki ga financira Ministrstvo za šolstvo, znanost in šport (MŠZŠ). Odobrena sredstva so bistveno manjša od predlaganih, tako da je bilo potrebno drastično krčenje zastavljenih raziskav. V okviru projekta poteka delo v štirih tematskih sklopih.

a) Taksonomske revizije

V okviru takšnih raziskav je izšla v zbirki Annales Majora knjiga o sesalcih Turčije in Cipra (Kryštufek, B., Vohralik, V., 2001. *Mammals of Turkey and Cyprus. Introduction, Checklist, Insectivora.* Knjižnica Annales Majora, Koper, 140 str.), ki obsega splošni del, popoln taksonomski seznam vseh 141 vrst sesalcev in taksonomsko revizijo žužkojedov (Insectivora). Izid dela je finančno omogočilo MŠZŠ. V teku so priprave na drugi del, ki bo obsegal glodalce (Rodentia). Boris Kryštufek si je v zadnjih letih v ta namen študijsko ogledal številne evropske zbirke in pripravil rezultate za to delo (npr. muzeji v Bonnu, Frankfurtu in Londonu).

V okviru taksonomskih revizij so bile opravljene tudi revizije beloprsega ježa *Erinaceus concolor*. Z dr. Rainerjem Huttererjem sodelujemo pri ovrednotenju taksonomskega položaja slabo znane rovke *Crocidura alexandrisi*, ki je endemična za Cirenajko v Libiji, po nekaterih mnenjih pa le mlajši sinonim široko razširjene palearktične vrtne rovke *Crocidura suaveolens*. Revidirali smo taksonomsko identiteto štirih tipskih primerkov rodu *Apodemus (Sylvaemus)* iz vzhodnega Sredozemlja in Irana. Rezultati so bili objavljeni v uglednih mednarodnih revijah.

b) Biodiverzitetni vzorci

Potekalo je delo na pregledu prostorskih vzorcev v gostoti in redkosti vrst evropskih glodalcev (Kryštufek, B., Griffiths, H. I.: *Species richness and rarity in European rodents),* za tisk je pripravljena analiza biodiverzitete sesalcev Balkana (Kryštufek, B.: *Assessment of the Balkan mammal diversity).*

c) Biodiverzitetni procesi

V središču zanimanja so odnosi med biodiverziteto, rastlinsko biomaso in načinom gospodarjenja oziroma opuščanja gospodarjenja. Procese preučujemo na traviščnih ekosistemih, z empiričnimi opazovanji, jemanju fitocenoloških popisov in na dveh eksperimentalnih površinah (eksperimentalna ploskev Vremščica in eksperimentalna ploskev Sv. Lovrenc pri Postojni).

Na Vremščici smo se v letu 2001 lotili poskusa, s katerim želimo ovrednotiti relacije med rabo tal, biodiverziteto in biomaso (podzemsko in nadzemsko) na kraškem sekundarnem pašniku. Pašnik je last Veterinarske fakultete, eksperiment pa poteka v sodelovanju s kolegi z Oddelka za agronomijo Biotehniške fakultete Univerze v Ljubljani. Kot rabo tal imamo v eksperimentu 3 različne načine paše ovac in opuščeno ploskev. Vzorčenje poteka na številnih podploskvah, vzorci se spirajo, sušijo in tehtajo, za reprezentančne vzorce biomase pa določamo tudi kalorimetrično in energijsko vrednost za podzemsko in nadzemsko biomaso. Prvi

rezultati kažejo, da v okolju z bogatim fondom vrst (species pool) tudi z intenzivnejšo rabo diverziteta flore bistveno ne pade, na ekstenzivno rabljenih ploskvah pa je podobna kot na (8 let) opuščenih ploskvah. Glede na življenjske oblike rastlin variira kalorimetrična vrednost podzemske biomase, kar kaže na posebne strategije fitocenoze, prilagojene poletni suši.

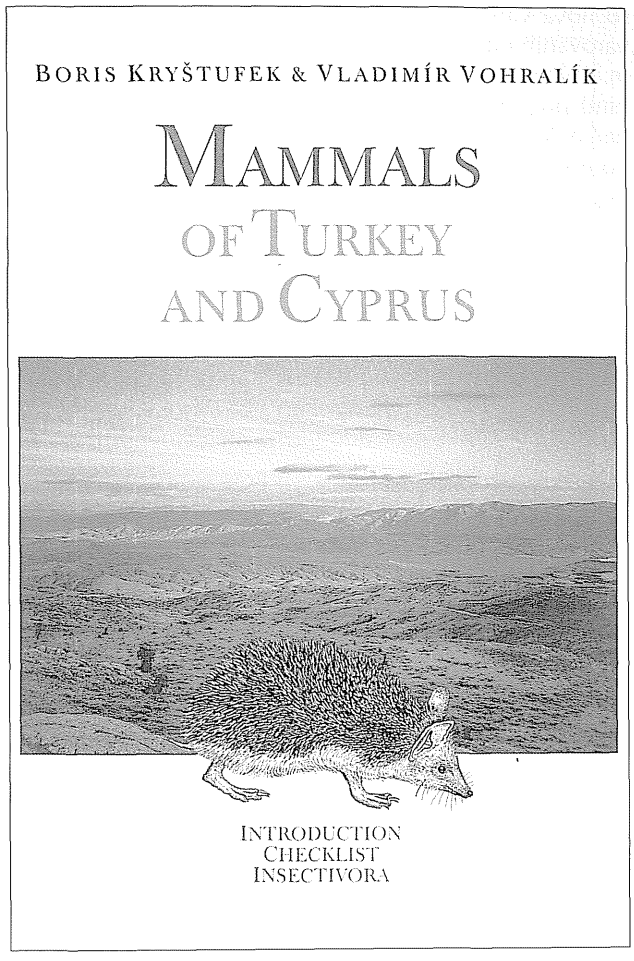
Z eksperimentom na eksperimentalni ploskvi Sv. Lovrenc pri Postojni želimo spoznati mehanizme zaraščanja travnikov. Velika površina v 60-ih letih opuščenih travnikov nam zagotavlja primerno eksperimentalno lokacijo, kjer smo določili več poskusnih ploskev in transektov. Ugotoviti želimo, kakšna je pri tem vloga velikih kobulnic *(Laserpitium siler, Grafia golaka),* ki na teh travnikih absolutno dominirajo. Poglavitna vprašanja, na katera iščemo odgovore, so predvsem: (1) ali kobulnice zavirajo ali pospešujejo zaraščanje, in (2) ali imajo kobulnice alelopatske učinke. Če jih imajo, na katere rastline in katere vrste pri tem največ pridobijo oz. izgubijo. Delo poteka v treh smereh. Po eni strani želimo ugotoviti natančne abiotske parametre, ki vladajo v tleh in v krošnji kobulnic kakor tudi zunaj njih, biomaso po transektih in odnose med biomaso in biodiverziteto. Po drugi strani smo zastavili dolgoročnejši eksperiment na zasenčenih, nezasenčenih, košenih in selektivno košenih ploskvah. Tretji segment dela poteka *ex situ*: v laboratoriju želimo dognati alelopatske učinke obeh kobulnic; prvi rezulati so spodbudni, saj smo učinke dokazali pri obeh vrstah. Nadaljujemo z eksperimentom v naravi, kjer izolirane alelopatske substance apliciramo na rastline *in situ,* da bi dokazovali njihovo samoodpornost na te substance.

d) Biodiverziteta "vročih točk"

Skupaj z dr. Rodom Baxtrom (Univerza Fort Hare, Alice, Južna Afrika) in dr. Wernerjem Haberlom je dr. Kryštufek že leta 2000 pripravil grob načrt raziskav biodiverzitetnih vzorcev v Vzhodni kapski provinci, Južna Afrika. Modelna skupina so mali terestrični sesalci (Insectivora, Rodentia). Februarja 2001 smo intenzivno delali v rezervatu Double Drift. Osnovni cilj raziskav je bil vzpostaviti monitoring za biodiverziteto travišč, ki so v razmeroma majhnem zavarovanem in izoliranem območju (40.000 ha) z obiljem rastlinojedih sesalcev (velike antilope, črni nosorog, svinje bradavičarke) brez ustreznih plenilcev potencialno izpostavljena prepaši in posledični degradaciji. V letu 2002 je potekalo delo v pogorju Amathole. Obe območji veljata v svetovnem merilu za "vroči točki".

e) Ciljni raziskovalni projekti

Na javni razpis za izbiro raziskovalno-razvojnih projektov Ciljnega raziskovalnega programa *"Konkurenčnost Slovenije 2001-2006"* smo prijavili predlog projekta *"Dolgoročni monitoring dveh ključnih vrst v gozdnem ekosistemu"*. Predlog projekta je MŠZŠ zavrnilo.



f) Program LIFE III-Nature

Na razpis EU v okviru programa LIFE III-Nature smo dobili projekt *"Ohranitev in varstvo ogroženih habitatov in vrst na območju načrtovanega Kraškega regijskega parka"*. Na projektu delata predvsem koordinatorja Andrej Sovinc in Bojana Lipej. Projekt, ki ga bomo na območju načrtovanega Kraškega regijskega parka uresničili v treh letih, obsega naslednje glavne sklope: Identifikacija pomembnih habitatov in vrst (poudarek na rastlinskih vrstah, dvoživkah in metuljih) z dodatkom k Direktivi o varstvu habitatov in vrst. Locirali in opisali naj bi 100 takšnih lokacij. Med habitati bo poudarek predvsem na suhih traviščih in kalih. Za 10 izmed omenjenih sto lokacij naj bi že vnaprej sklenili dogovore z lastniki zemljišč, da so pripravljeni – v zameno za določeno finančno odškodnino – upravljati/gospodariti s temi lokacijami na način, kot bo predpisal v posebej za posamezno lokacijo napisan "upravljalski načrt". Poleg teh 10 lokacij naj bi takšne dogovore sklenili še za dodatnih 20 lokacij, ki bodo identificirane v okviru projekta (lokacija, opis habitata in vrst, upravljalske smernice). Za še nadaljnjih 70 lokacij pa bi pripravili le upravljalske načrte. Na omenjenih lokacijah (na 30 izmed njih) naj bi nastali *t.i.* "mikro-rezervati", ki

so nova varstvena kategorija v slovenskem sistemu zavarovanih območij, saj temeljijo na zasebnem lastništvu in zavezanosti lastnika zemljišča, da je (proti odškodnini) pripravljen upravljati/gospodariti z zemljiščem na način, kot bo predpisan v "upravljalskem načrtu". Gre za območja, ki v okviru varstvenega režima, kot ga ponuja Regijski park (IUCN kategorija zavarovanega območja V.), zahteva še poseben način upravljanja za ohranitev določenih habitatov in/ali vrst. Projekt bo spremljala tudi kampanja za osveščanje javnosti o pomenu "mikro-rezervatov" (video film, zgibanke, informativni prispevki in članki ipd.), posebni informativni sestanki/delavnice, urejen pa naj bi bil tudi preprost "center za obiskovalce" s stalno razstavo o mikro-rezervatih. V okviru projekta bo dana tudi možnost odprtja novih delovnih mest za lokalno prebivalstvo.

Projekt naj bi postal model razvoja mreže mikro-rezervatov za celotno Slovenijo.

V prihodnosti načrtujemo delo na vseh že začetih projektih, prijavljali pa smo tudi nove nacionalne projekte in izrazili interes za sodelovanje v 6. evropskem okvirnem programu za projekt *"Hydro-Carbo-Mont"*, ki se koordinira iz Innsbrucka; k preučevanju ekoloških parametrov, predvsem kroženju ogljika, vodnega režima, upravljanja in biodiverzitete travišč v evropskih gorovjih smo k številnim evropskim gorovjem dodali Dinaride z našim Snežnikom.

Transekt od morja do Snežnika je raziskovalno območje novega projekta, kjer bi zasledovali različne parametre biodiverzitetnih vzorcev in dinamike na izbranem altitudinalnem gradientu, ki dosega naravno gozdno mejo na Snežniku.

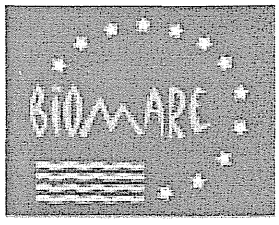
V aplikativnem delu tega projekta bi se radi posvetili tudi nekaterim prostorskim problemom na območju občine Izola (prehod morje-kopno, koncept "umetnega otoka", varovanje in vzdrževanje tradicionalne kulturne krajine, izraba in varovanje obalnega pasu ipd.).

Vizije in načrti IBŠ so veliki, saj izzivov ni treba iskati daleč; v biogeografsko tako enkratnem prostoru je dovolj nerešenih znanstvenih problemov, naravovarstvenih izzivov in klicev po konkretnih aplikacijah v prostoru, pri katerih IBŠ lahko in mora dati ustrezne strokovne rešitve!

Carlo Heip & Alenka Malej

THE EUROPEAN MARINE RESEARCH STATIONS AND BIODIVERSITY RESEARCH

Europe has the longest coastline of all continents relative to its surface and over half of the EU citizens live close to the coast. The oceans cover 70 % of the Earth's surface and to a large extent determine the way in which our planet functions and supports life, particularly human. The oceans determine our weather and climate, and society relies on the seas for transport, energy, food and mineral resources, waste treatment and, especially in Europe, leisure.



Marine Research Stations: a unique part of Europe's scientific patrimonium

When Charles Darwin published the Origin of Species, public and scientific interest in biology soared. This led to the creation of a number of laboratories with facilities to study marine life in many European countries during the last part of the nineteenth century. Some of the earliest and best known are the Stazione Zoologica in Naples, the stations of Villefranche, Banyuls and Roscoff in France, the Marine Biological Association's laboratory in Plymouth and the Biologische Anstalt Helgoland in Germany, to name just a few.

Over more than a century these marine research institutes have been the main centres were scientists, students and laymen alike could have a direct access to the sea and to the laboratories where marine plants and animals could be studied alive. Many Nobel prices honouring fundamental discoveries in physiology and biochemistry have been earned through work in the marine stations, and tens of thousands of biologists, physiologists, ecologists and scientists from many other disciplines in Europe received their basic training in marine sciences at one of the numerous marine stations.

The MARS network

At the meeting held in 1996 in Paris, directors of more than 40 marine research stations decided to create a foundation to coordinate their interests at the European level and to make a better use of the facilities at the stations: oceanographic research vessels, specialized experimental laboratories, libraries and collections, and access to specific biological communities in the seas. These forty-odd marine research stations cover all the coasts of Europe, from the high Arctic in Svalbard in the north, to the Canary Islands and the Azores in the south, and to Turkey and Israel in the eastern Mediterranean.

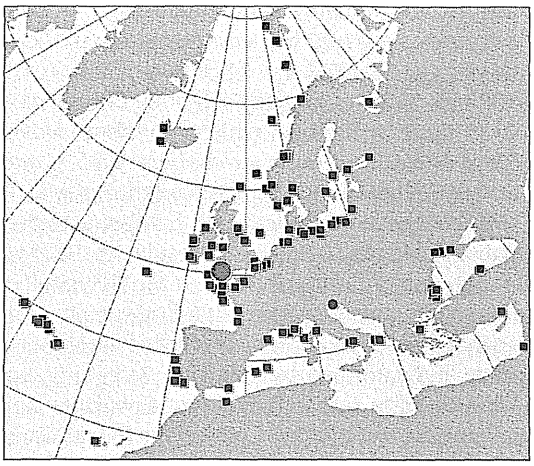
Besides making facilities accessible at the European level, the MARS network also started a scientific research initiative that would build on the unique characteristics of the marine institutes. In 2000 in Venice,

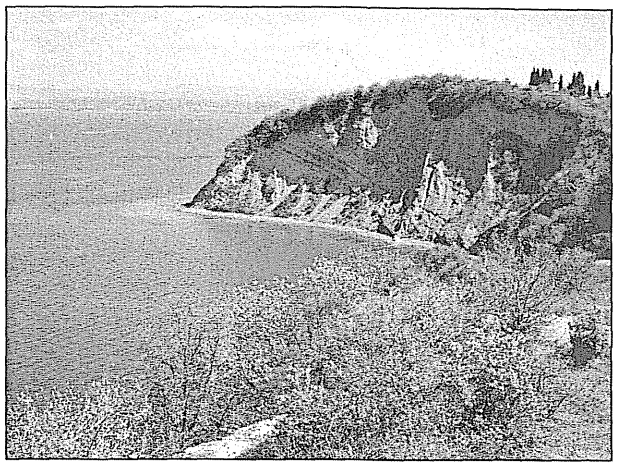
NR STRUNJAN & NM CAPE MADONA, SLOVENIA

Slovenia

Conservation status

☆ ☆ ☆ ☆ ☆





Nature Reserve Strunjan, Slovenia. Photo L. Lipej

Co-ordinates: 45°32′ N 13°35-37′W

Description of site:

Nature Reserve Strunjan and Natural Monument Cape Madona are two marine protected areas beneath typical flysch cliffs. Both sites are characterized by a variety of habitats and specific abiotic conditions which reflects the high biodiversity of the area.

Habitats present:

	Mud	Sand	Rock
Littoral		X	X
Sublittoral	X	X	X
Seagrass beds		X	

Description of fauna and flora:

The intensive mapping and monitoring of the fauna and flora of the Slovenian coastal sea in going on from 1998. Up to date at least 1,700 species of animals were recorded for the area.

Human impact:

The proposed sites are facing some anthropogenic impacts such as nautic traffic, angling and bathing. Despite the protected status of both sites, the illegal harvesting of protected mussels is still ongoing.

Facilities:

All facilities are available in the nearby Marine Biology Station, which is equipped for all aspects of biodiversity research (labs, SCUBA diving facilities, research equipment, boats and vessels).

Available database and website:

The inventory of fauna and flora is held at the Marine Biology Station (NIB). The websites regarding both marine protected areas are available at http://projects.msp.nib.si/Tunis2000/ and http://dragonja.nib.si.

Commitment and ongoing research:

The Marine Biology Station Piran (National Institute of Biology) is undertaking the biodiversity research in the proposed sites and in other parts of the Gulf of Trieste (northern Adriatic).

marine biodiversity was chosen as the first priority issue. The reasons are obvious. Fisheries are in crisis. Marine species in general are disappearing at a rate never observed since life began on Earth. The extinction crisis ranks, together with global climate change, as the greatest threat to the integrity of the biosphere in the 21st century. Species extinction is not just an aesthetic or moral problem. Marine organisms play a crucial role in almost all biogeochemical processes that sustain the biosphere, and provide a variety of products (goods) and functions (services) that are essential to mankind's well-being, including the production of food and natural substances, the assimilation of waste, the remineralisation of organic matter and the regulation of the world's climate.

MARS and the European Research Area

The scale of the research efforts needed to obtain adequate knowledge for exploration, conservation and restoration of marine biodiversity demands European-scale collaboration. The European Commission came out with its initiatives as early as 1995 and began to cooperate on this issue with the Marine Board of the European Science Foundation and MARS that led to a series of marine policy documents (http://www.esf.org/) culminating in 2000 in the concerted action BIOMARE (http://www.biomareweb.org). The objectives of BIOMARE are to establish a network of research sites and a series of indicators for biodiversity as the basis for long-term and large-scale marine biodiversity research in Europe. Through the three global initiatives, *i.e.* the International Biodiversity Observation Year IBOY, DIVERSITAS and the Census of Marine Life CoML, BIOMARE has attracted attention worldwide as a major effort to coordinate biodiversity research at the European scale and beyond.

Within the *Fifth Framework Programme* another important networking effort MARBENA will run till 2004 (http://www.vliz.be/marbena/). This project specifically extends the previous actions to the Newly Associated States and will feed directly into EU policy via a series of electronic conferences linked with the European Platform for Biodiversity Research and Strategy (EPBRS).

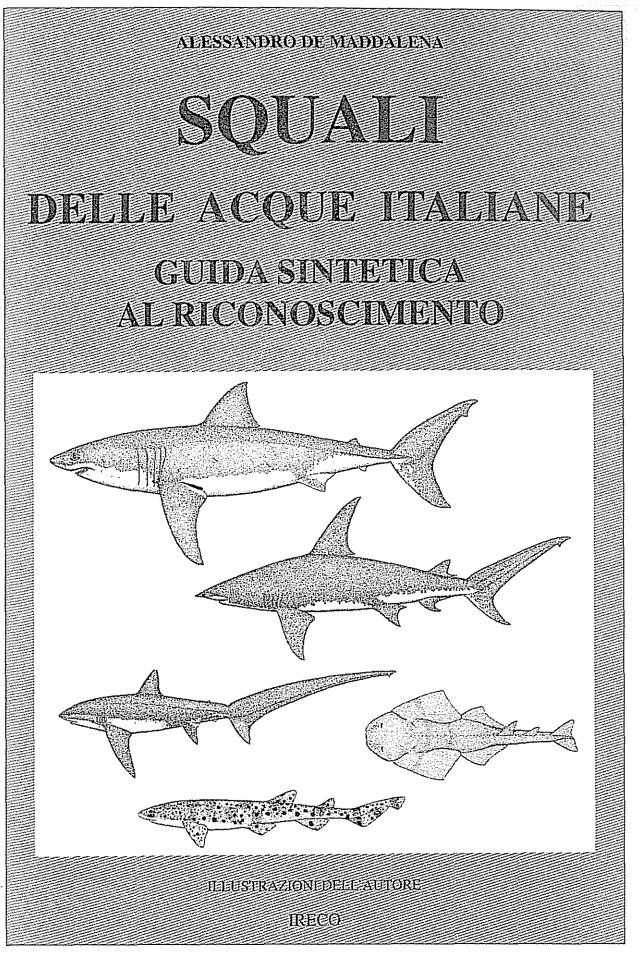
Finally, within the *Sixth Framework Programme* the issue of biodiversity and ecosystems has grown to become one of the main research actions, with well received expressions of interest for networks and projects in marine biodiversity, marine genomics and marine biogeochemistry issued from the MARS member stations. It shows that in the European Research Area, which is now taking shape, the role of the marine research stations will continue to be important and that these stations will remain an important asset of Europe to fulfil its role as a world leader in the study of the seas and oceans.

The Piran Marine Biology Station (MBS) of the National Institute of Biology, which represents Slovenia in MARS, is one of its founding members. MBS is one of the partners involved in the Concerted Action BIOMARE, which has brought together European expertise in marine biodiversity. The main results of BIOMARE are: 1) a network of European Marine Biodiversity Focal Sites as a basis for long-term and large-scale marine biodiversity research in Europe; 2) a set of measures and appropriate indicators of biodiversity; 3) setting up of marine biodiversity research in Europe website and a biannual printed newsletter. One of the Focal Sites in the Mediterranean, proposed by MBS, is located in the Gulf of Trieste and comprises two marine protected areas: the Cape Madona Natural Monument and the Strunjan Nature Reserve (see box on previous page). MBS is also a partner of a follow-up project MARBENA, which will assist further development and implementation of biodiversity knowledge obtained through BIOMARE. MARBENA aims at establishing a pan-European network of excellence including marine scientists as well as other stakeholders in marine biodiversity issues and at enlarging the transparency of marine biodiversity research in Europe. And finally, MBP participates in the BioPlatform network, which is developing the European platform for Biodiversity Research and Strategy that in 2002 extended to include NAS countries (Newly Associated Countries to EU).

For further information you are kindly invited to consult the MARS web page: www.marsnetwork. org or to get in contact with Prof. Carlo Heip, President of MARS, c.o. Netherlands Institute of Ecology, P.O. Box 140, 4400 AC Yerseke, The Netherlands (e-mail: c.heip@nioo.knaw.nl.) or Prof. Alenka Malej, MBS NIB, Fornače 41, 6330 Piran, Slovenia (malej@nib.si), and MBS web page http://www.msp.nib.si.

OCENE IN POROČILA/RECENSIONI E RELAZIONI/REVIEWS AND REPORTS, 269-273

OCENE IN POROČILA
RECENSIONI E RELAZIONI
REVIEWS AND REPORTS



Alessandro De Maddalena: SQUALI DELLE ACQUE ITALIANE. GUIDA SINTETICA AL RICONOSCIMENTO. IRECO, Formello, 2001, 72 pp.

Alessandro De Maddalena, the Italian shark specialist, had a key to identification of sharks in the Italian seas published in 2001. In a neatly designed booklet, supplemented by superb author's drawings, he presented all shark species occurring in Italian waters. The main objective of the booklet is a quick identification of sharks. Initially, the author acquaints us with some basic details about the anatomy and morphology of sharks, and eventually presents the booklet's major part, the identification key. The author did not opt for a classical dichotomous key, but offers several possibilities of elimination at the same time. Here it should be stressed that the key is intended for a wide range of readers, who are immediately advised to reach for specialist works if more thorough knowledge is required.

Although a dichotomous key would no doubt be more appropriate, the author's unusual approach is very transparent and indeed fulfils its purpose – a quick identification of a selected shark species. The most extensive part of the booklet is dedicated to a detailed description of separate species. Each of them is presented with an accurate drawing and, below the picture, with its basic morphological characteristics, colour features and size. There follow details about its habitat, reproduction and dietary characteristics. Each description is concluded with a few words about the species's significance for fisheries and danger to humans. After describing all sharks occurring in the Italian seas, the author presents a form to be filled if we wish to cooperate with professional organisations dealing with sharks. This is followed by photographs which, however, may be superfluous, considering that they more or less depict sharks' cadavers, which are of course of no particular use to the readers. The concluding chapter deals with the used bibliography and index of terms.

The manual is certainly an important contribution to the Italian ichthyological literature. The simple, nicely designed and not too extensive booklet serves as a perfect basis for the identification of sharks. And its greatest quality are indubitably the author's drawings.

Lovrenc Lipej

Giovanni Nikiforos: FAUNA DEL MEDITERRANEO – GUIDA COMPLETA. Giunti Gruppo Editoriale, Firenze, luglio 2002, 366 pp.

Appassionato come sono del mondo marino, recentemente ho avuto modo di acquistare un libro fresco di stampa, ossia una nuova guida alla conoscenza della fauna marina del Mediterraneo. Il volume è un'opera esaustiva che comprende più di 3.500 specie di animali che popolano il Mar Mediterraneo.

Purtroppo non sono riuscito a trovare alcuna informazione sull'autore di quest'opera, al quale bisogna riconoscere il merito di aver fatto una guida veramente facile da consultare anche per gli appasionati dell'ambiente marino meno esperti, grazie anche al fatto che la descrizione di ogni singola specie viene accompagnata da un'illustrazione a colori.

Nella prima parte del libro troviamo una sintesi della storia e delle caratteristiche fisiche del Mediterraneo, nonché la descrizione dei piani e delle zone in cui viene suddiviso l'ambiente marino. L'autore ha inserito anche le descrizioni dei gruppi in cui vengono suddivisi gli organismi marini e dei vari tipi di fondale e ha in breve spiegato i concetti di catena e di piramide alimentare. La seconda parte del libro è invece incentrata sulle principali caratteristiche morfologiche dei phylum che appartengono al regno animale e sull'inquadramento sistematico.

Di seguito troviamo le tavole illustrate che si distinguono per la loro organizzazione estremamente pratica e perciò di facile consultazione anche per le persone prive di alcuna nozione di biologia. Gli organismi, infatti, non vengono suddivisi seguendo l'ordine sistematico ma in base alla loro morfologia. Per esempio, esistono delle tavole che trattano gli animali con corpo vermiforme (molluschi, vermi, echinodermi) oppure gli animali di aspetto inconsueto (spugne, tunicati, cnidari). Un'altra caratteristica positiva delle tavole è il fatto che la descrizione delle specie si trova sempre sulla pagina sinistra (pari) mentre l'illustrazione corrispondente è sulla destra (pagina dispari). Le illustrazioni possono apparire a prima vista un po' semplicistiche, ma in realtà riproducono molto bene le caratteristiche morfologiche e cromatiche principali dell'organismo descritto. Nel volume si possono comunque trovare delle inesattezze o degli errori ai quali faranno probabilmente caso soltanto i più esperti del campo, ma la guida rappresenta senz'altro un'ottimo punto di partenza per una migliore classificazione delle specie osservate in mare. Talvolta si renderà comunque necessario l'utilizzo di altre chiavi di determinazione.

Le illustrazioni a colori di ogni specie descritta rappresentano davvero un grande vantaggio per il lettore. Personalmente sono rimasto molto colpito dal gran numero di opistobranchi trattati nella guida.

Nell'ultima parte del libro troviamo delle tavole in cui vengono fatti dei confronti dimensionali e una proposta dell'autore per la preparazione di un elenco dei nomi volgari dei pesci ossei del Mediterraneo. Immancabili il glossario e la bibliografia.

Per concludere, la guida assomiglia in parte al volume *"Fauna und Flora der Adria"* di R. Riedel (Paul Parey Verlag, 1963), ma è basata su un diverso concetto. Innanzi tutto comprende solo la fauna marina, le illustrazioni sono sì a colori ma per questo meno precise di quelle del Riedl, e per finire include anche specie nuove, scoperte da poco (ad esempio *Gobius kolombatovici).* Il volume inoltre menziona anche i migranti lessepsiani, e non solo fra i pesci. All'autore va pertanto riconosciuto il merito di stare al passo con le novità tassonomiche e faunistiche del Mediterraneo, dote che non dovrebbe mancare a nessun autore che voglia preparare un buon libro.

Samo Alajbegović

Alessandro De Maddalena: LO SQUALO BIANCO NEI MARI D'ITALIA. IRECO, Formello, 2002, 144 pp.

Alessandro De Maddalena is a devoted researcher into the biology of sharks, particularly the infamous Great White Shark. His latest book is in fact the fulfilment of the project entitled "Banca Dati Italiani Squalo Bianco", in which he gathered numerous data on the occurrence of the Great White Shark *(Carcharodon carcharias)* in Italian waters.

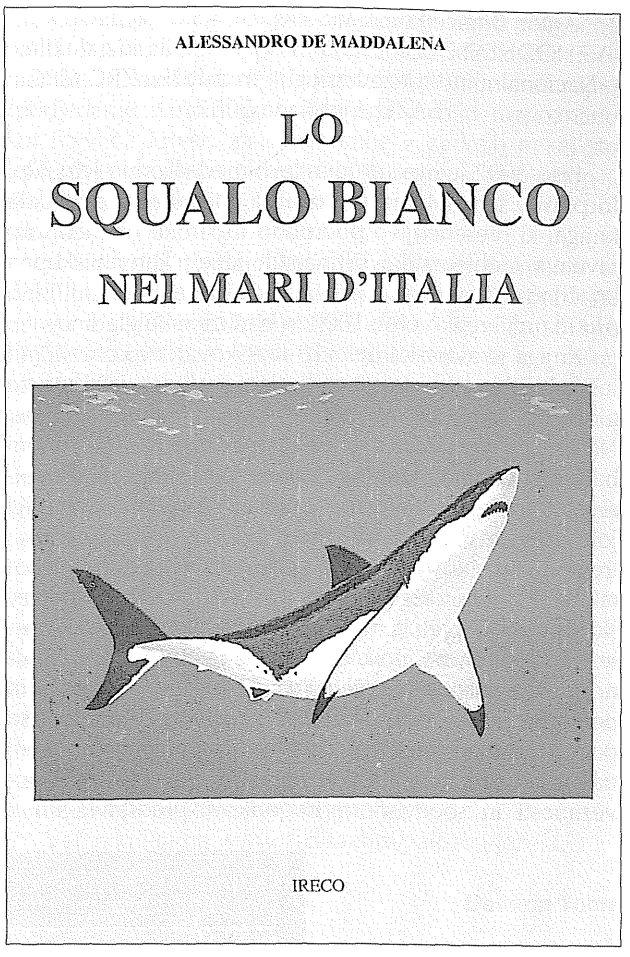
On this occasion I must stress that Alessandro is far from a sensationalist dealing with this shark merely for the fact that it is the most dangerous shark species in the world in general. I would sooner characterise him as an attentive researcher who has decided to break the stereotypes about this man-eater, as referred to in some places. It could be said, in fact, that he deals with the Great White Shark as with one of the victims of man, who has greatly decimated it in the last few years.

On the basis of data and pictorial material collected

in the last six years, Alessandro made 402 records dealing with 436 individuals of the Great White Shark in the Mediterranean. The book is no doubt the most complete work about the Great White Shark in the Italian seas. The numerous photographs speak of the fact that this shark is a reality we simply must be confronted with. To certain cases the author devoted as much of his attention as there were data available to him. In fact, he carried out a precise work of a chronicler.

The book is divided into six chapters dealing first of all with descriptions of the Great White Shark, encounters with it in Italian waters, analysis of its presence in the Italian seas, possibilities of cooperation in the collection of the shark's data, conclusions, and bibliography. In the introductory part we get well acquainted with the sharks of the family Lamnidae, their diagnostic characteristics, basic features with regard to their anatomy, morphology, size, diet, geographical distribution, and relations with humans. A very special feature of this chapter are the author's exceptional drawings. The most attractive is certainly the second chapter, for in it the author described, with the accuracy of a chronicler, all the available data on the Great White Shark's encounters with humans, with references even to the year 1666. The author present the data of this species per separate seas and larger islands (Sicily, Sardinia, Ligurian, Tyrrhenian, Ionic and Adriatic Seas). Most often, these encounters did not end well for the shark, as demonstrated by the author's rich photographical material, while in some of the accounts the author describes dangerous encounters with the Great White Shark under the water, which in some cases ended most tragically. I would also like to stress that Alessandro presents in his book several excellent shots of the shark made especially in the last few years by eyewitnesses. For these shots speak that in spite of the terrible decimation of the species in the last century, the Great White Shark is still an inhabitant of the Adriatic Sea.

In the next chapter, an analysis of the occurrence of the Great White Shark in the Italian seas is presented. Most of the details originate from the Tyrrhenian Sea and coastal waters of Sicily, which is quite understandable considering that tuna fishing is still practised there. We also get to know that the Great White Shark appeared most frequently in the summer months, usually preying on big fish like tuna or swordfish and dolphins. It may be interesting to note that the author states some cases of these sharks feeding on carrion; they were taken by surprise when gorging on dead spermwhales and finwhales.



The conclusions and indeed extensive references are followed by a survey of all documented cases dealing with the Great White Shark. The reader can be here acquainted with an impressive data collection, which is in fact a basis of this work.

The book about the Great White Shark in Italian waters is a comprehensive presentation of this shark both from the aspect of its occurrence and ecology in the area of the Central Mediterranean and from the aspect that speaks of its interaction with man, which almost always ends tragically for the shark. Although the book is indubitably of great professional value, it will be welcomed by all those biologists, divers, lovers of the sea and nature in general who are simply enraptured by super predators. And the fact is that the Great White Shark plays a very similar role as the lion on the savanna or the tiger in the jungle.

Lovrenc Lipej

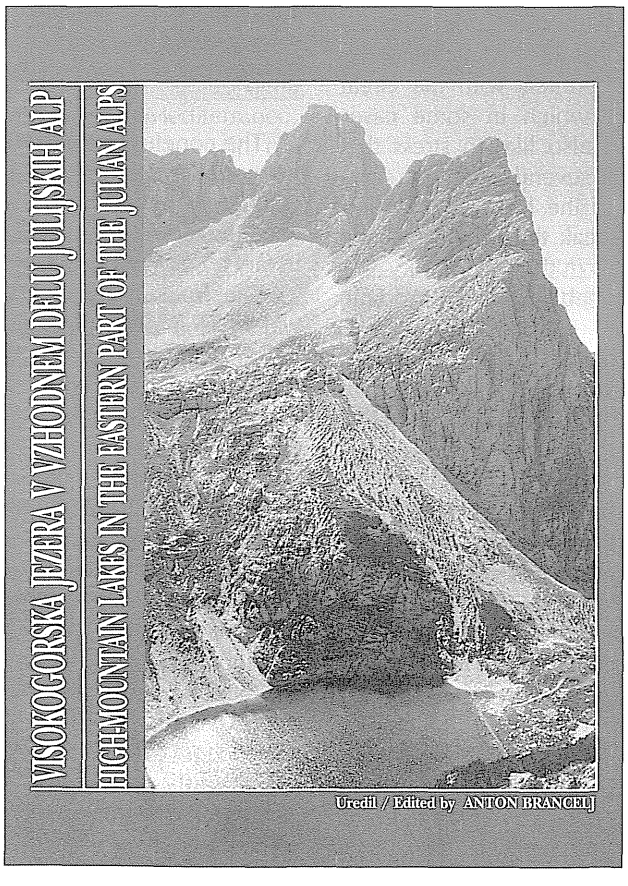
Anton Brancelj (ur.): VISOKOGORSKA JEZERA V VZHODNEM DELU JULIJSKIH ALP. Izdala in založila: Nacionalni inštitut za biologijo in založba ZRC, ZRC SAZU. Ljubljana 2002.

Leto 2002 je med drugim tudi mednarodno leto Alp. In prav v tem letu je v Sloveniji luč dneva zagledala knjiga, ki presenetljivo podrobno in široko obenem obravnava problematiko štirinajstih jezer, katerih skupna značilnost je ta, da vsa ležijo v slovenskem delu Julijskih Alp in tudi krepko prek 1000 m nad morsko gladino.

Knjiga je avtorsko delo 18 raziskovalcev iz različnih inštitucij, ki so v organizaciji Nacionalnega inštituta za biologijo okroglih 10 let raziskovali alpska jezera. Natisnjena je na 268 straneh, opremljena s številnimi barvnimi fotografijami, večje količine podatkov so smiselno in pregledno urejene v tabelah in grafih. Sestavlja jo 13 poglavij in vsako izmed njih obravnava te ekstremne vodne ekosisteme s svojega lastnega zornega kota. Pred bralca razgrnejo vse, od sociološko-gospodarskega vidika, prek geografskih, fizikalno-kemijskih osnov in zanimivosti do bioloških danosti. Posebno vrednost daje prispevkom četrta dimenzija - podrobna in dolgoročna časovna dinamika procesov. Besedila so podana z dovolj širine, da s poznavanjem osnovnih naravoslovnih zakonitosti brez večjih težav sledimo povezanosti in soodvisnosti dogodkov, predstavljenih v različnih poglavjih. Drugače izobraženi lahko prepletenost spoznajo v zadnjem, štirinajstem poglavju, zaključku, ki na enem mestu poljudno poveže vsa nova spoznanja v knjigi. Besedilo je natisnjeno dvojezično, slovensko in angleško - tematika in izsledki pač presegajo jezikovno začrtane meje znotraj Evrope.

Po uvodnih besedah in predstavitvi kratke zgodovine dosedanjih raziskav na območju Alp v drugem poglavju zvemo vse o klimatskih razmerah raziskanega območja z zaledjem – značilnosti iz časa raziskav so zelo natančno opisane s pomočjo podatkov, zbranih s sodobnimi merilnimi inštrumenti, več kot 100 let stara vremenska dogajanja pa s pomočjo zapisov v drevesnih letnicah.

Poglavje o triglavskem ledeniku na prvi pogled morda ne sodi v knjigo, ki je posvečena jezerom, pa vendar. Leži v njihovi neposredni bližini, rezultati desetletij raziskav večnega ledu (poglavje sicer daje temu izrazu za triglavski ledenik precej posmehljiv ton) pa poleg drugega dodatno opisujejo in pojasnjujejo zgodovinski presek klimatskih sprememb v visokogorju, ki so pomembno vplivale tudi na jezera. In ne nazadnje, eno izmed naslednjih poglavij, poglavje o hidroloških podzemnih povezavah med nekaterimi jezeri, nam postreže s številnimi presenečenji, tako da bo povezava stopljene ledeniške vode z niže ležečimi visokogorskimi jezeri, ki jo bodo morda nekoč odkrili, le eno izmed mnogih presenečenj v vrsti.



Visokogorski jezerski ekosistemi so v primerjavi z nižinskimi dokaj revni s hranili. Organska masa na okoliških vršacih je majhna, tako da je s spiranjem v vodno telo ne pride kaj dosti. V poglavju o mineralizaciji izvemo, da to še posebno velja za jezera, ki so odmaknjena od planšarij. V vodah je zato toliko bolj pomembna primarna produkcija, ki pa je seveda odvisna od svetlobe. Koliko sončevega obsevanja je deležno vsako izmed jezer, je v poglavju o legi in opisu jezer zelo nazorno predstavljeno s preprosto skico, dodani pa so tudi osnovni podatki o nadmorski višini, globini, obsegu jezer ipd. ter izčrpni opisi jezerske podlage, dinamike in drugih posebnosti. Zelo podrobna je tudi predstavitev fizikalno-kemijskih lastnosti vode, vključno s trajanjem ledenega pokrova. Kar polovico leta imajo zamrznjeno gladino najniže ležeča jezera, najvišje ležeče Kriško jezero pa celo tri četrtine leta. In kar je verjetno še bolj zanimivo, je dejstvo, da kljub vsemu v jezerih obstaja bujno življenje – planktonske, bentoške alge, makrofiti, planktonske ter bentoške živali, tudi ribe. Vsaki izmed skupin je posvečeno posebno poglavje.

Predzadnji sklop, v katerem so tri poglavja, je prava detektivska zgodba v malem. Predstavljajte si, da ste sredi lično pospravljene, že dolgo časa zapuščene sobe, ugotoviti pa morate, kaj se je v njej dogajalo pred 100 leti. Avtorji poglavij – naravoslovni detektivi – so *t.i.* paleorazmere preučili s pomočjo podatkov, ki so jih iztrgali globoko iz jezerskih sedimentov. Poskušali so ugotoviti, katere vrste živali in katere alge so bile nekoč pogoste, ugotavljali so tudi vzroke sprememb. Na zatožni klopi so se znašle, ramo ob rami, mogočne naravne sile, kot so plazovi, potresi, klimatske spremembe in tudi človek – njegovo slabotno, a vztrajno spodjedanje naravnega ravnovesja je bilo razpoznano kot največji krivec za spremembe v zadnjih nekaj sto letih. Prav pregledu človekovih posegov v visokogorski svet in s tem tudi v jezera je namenjeno zadnje poglavje.

V Sloveniji ni malo knjig, posvečenih Alpam. V ta svet nas vodijo peresa, pisanja veščih alpinistov in peresa v planine zaljubljenih literatov. Številne so tudi knjige fotografij, in če le tem prištejemo še po nekaj planinskih koledarjev na leto, planinske vodnike ter zemljevide, lahko mirne duše zatrdimo, da je publicistična dejavnost s tematiko Alp pri nas zelo plodna. Pa vendar je knjiga o alpskih jezerih zaorala globoko ledino: med "alpskimi" publikacijami, ker nam ta svet predstavlja na povsem svež način, in tudi med domačimi naravoslovno-znanstvenimi publikacijami, predvsem zaradi širine raziskovalnega pristopa. Če sodite med tiste, ki želite od naravoslovne knjige nekaj več kot samo počitek za oči ali podstavek za projektor, jo boste z užitkom prelistali in marsikatero poglavje z zanimanjem tudi prebrali. Ne tako redki pa se boste ob fotografijah v knjigi tudi spomnili, da ste pred leti ob poti na Triglav pravzaprav res srečali nenavadne planince z vesli in čolnom v nahrbtniku.

Več o knjigi na www.zrc-sazu.si/zalozba/jezera.

Davorin Tome

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Metuljčnici *(Libelluloides macaronius)* med kopulo na prisojnem travniku na robu vasi Abitanti v Slovenski Istri (foto: T. Makovec).

Sl. 1: Razgibani, terasasti svet Slovenske Istre zagotavlja zanimive življenjske niše za mnoge toploljubne živali, med drugim tudi za metuljčnico *(Libelluloides macaronius)* (foto: D. Podgornik).

Sl. 2: Rjavi škarpoč *(Scorpaena porcus)* pogosto prikrito ždi na dnu in preži na plen (foto: T. Makovec).

Sl. 3: Dolgonosi morski konjiček *(Hippocampus guttulatus)* je ogrožena vrsta obrežnih rib, ki naseljuje morske travnike (foto: T. Makovec).

Sl. 4: Intenzivnost poljedelske pridelave ima močan vpliv na plevelno floro in vegetacijo določenega območja (foto: D. Podgornik).

Sl. 5: Oljka *(Olea europaea)* že tisočletja uspeva v sredozemskem bazenu, kjer je ena najpomembnejših gojenih sadnih vrst (Foto: D. Podgornik).

Sl. 6: V inventarju slovenskih mokrišč je popisanih 3525 mokrišč, ki pokrivajo slabih 5% površine Slovenije (foto: L. Lipej).

Sl. 7: Rosnica *(Rana dalmatina)* je najpogostejša vrsta rjavih žab v kraških kalih (foto: T. Makovec).

Sl. 8: Ogenj je v sredozemskem ekosistemu pomemben ekološki dejavnik, ki spreminja habitatne tipe (foto: D. Podgornik).

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FRONT COVER: Owl Flies *(Libelluloides macaronius)* in copula on a sunward grassland along the village of Abitanti in Slovene Istria (photo: T. Makovec).

Fig. 1: The multiform, terraced countryside of Slovene Istria provides some interesting life niches for a number of thermophilous animals, including the Owl Fly *(Libelluloides macaronius)* (photo: D. Podgornik).

Fig. 2: Black Scorpionfish *(Scorpaena porcus)* often lurks at the bottom of the sea, waiting for prèy (photo: T. Makovec).

Fig. 3: Long-snouted Seahorse *(Hippocampus guttulatus)* is an endangered coastal fish species, inhabiting sea meadows (photo: T. Makovec).

Fig. 4: Intensive farming has a strong impact on the weed flora and vegetation of a certain area (photo: D. Podgornik).

Fig. 5: Olive *(Olea europaea)* has been thriving in the Mediterranean basin for millennia and has always been one of the most important cultivated fruit species in the region (photo: D. Podgornik).

Fig. 6: In the inventory of Slovene wetlands, 3,525 wetlands are listed, covering a little less than 5% of the entire surface area of Slovenia (photo: L. Lipej).

Fig. 7: Agile Frog *(Rana dalmatina)* is the most common karst pond brown frog (photo: T. Makovec).

Fig. 8: In the Mediterranean ecosystem, fire is an important ecological factor, changing the habitat types (photo: D. Podgornik).

NAVODILA AVTORJEM

1. ***ANNALES:*** *Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istran and Mediterranean Studies* (do 5. številke: *Anali Koprskega primorja in bližnjih pokrajin - Annali del Litorale capodistriano e delle regioni vicine - Annals of the Koper Littoral and Neighbouring Regions)* je znanstvena in strokovna interdisciplinarna revija humanističnih, družboslovnih in naravoslovnih vsebin v podnaslovu opredeljenega geografskega območja.

2. Sprejemamo prispevke v slovenskem, italijanskem, hrvaškem in angleškem jeziku. Uredništvo ima pravico prispevke jezikovno lektorirati.

3. Prispevki naj obsegajo največ 24 enostransko tipkanih strani s po 30 vrsticami. Na levi pustite 3 do 4 cm širok rob. Zaželjeno je tudi (originalno) slikovno gradivo, še posebno pa oddaja prispevka na računalniški disketi v programih za PC (osebne) računalnike.

4. Naslovna stran tipkopisa naj vsebuje naslov in podnaslov prispevka, ime in priimek avtorja, avtorjeve nazive in akademske naslove, ime in naslov inštitucije, kjer je zaposlen, oz. domači naslov vključno s poštno številko in morebitnim naslovom elektronske pošte.

Uredništvo razvršča prispevke v naslednje **kategorije:**

Izvirni znanstveni članki vsebujejo izvirne rezultate lastnih raziskav, ki še niso bili objavljeni. Dela pošlje uredništvo v recenzijo. Avtor se obvezuje, da prispevka ne bo objavil drugje.

Pregledni članki imajo značaj izvirnih del. To so natančni in kritični pregledi literature iz posameznih zanimivih strokovnih področij.

Predhodno sporočilo in *Gradiva* imajo ravno tako značaj izvirnih del.

Strokovni članki prikazujejo rezultate strokovnih raziskav. Tudi te prispevke uredništvo pošlje v recenzijo in avtor se obveže, da prispevka ne bo objavil drugje.

Poročila vsebujejo krajše znanstvene informacije o zaključenih raziskovanjih ali kratek opis strokovnih in znanstvenih knjig ali srečanj. Taki prispevki ne smejo presegati 5 strani.

Mladinske raziskovalne naloge morajo biti urejene kot strokovna dela.

Komentarji so namenjeni aktualnostim s strokovnega področja. Ne smejo presegati 2 strani.

Obvestila so namenjena društvenemu življenju. Obsegajo 1 stran.

5. Prispevek mora vsebovati **povzetek** in **izvleček.** Izvleček je krajši (cca. 10 vrstic) od povzetka (cca. 30 vrstic) in v nasprotju s povzetkom tudi ne vsebuje komentarjev in priporočil.

V *izvlečku* na kratko opišemo namen, metode dela in rezultate. Navedemo, čemu smo delo opravili ali napisali dokument. Na že objavljeno gradivo se sklicujemo le, če je to glavni motiv dela. Na kratko opišemo metode in tehnike dela - kolikor je potrebno za razumevanje. Nove tehnike opišemo le, kjer se razlikujejo od že znanih. Če v delu ne opisujemo eksperimentalnega ali praktičnega dela, opišemo vire informacij. Rezultate in zaključke lahko združimo. Kar se da informativno navedemo le, kaj smo ugotovili oziroma odkrili.

Povzetek začnemo s stavkom, ki vsebuje glavno sporočilo dela. Stavki naj bodo popolni in ne predolgi. Pišemo v tretji osebi, le izjemoma uporabimo glagole v neosebni obliki. Uporabljamo pravilni strokovni jezik in se izogibamo slabše znanim kraticam. Ohraniti moramo osnovno informacijo in poudarke iz glavnega besedila. V povzetku ne sme biti ničesar, česar glavno besedilo ne vsebuje.

6. Avtorji so dolžni definirati in pripisati ustrezne **ključne besede** (pod izvlečkom) članka. Zaželjeni so tudi **angleški (ali slovenski) prevodi** ključnih besed, podnapisov k slikovnemu in tabelarnemu gradivu. Priporočamo se še za angleški (ali slovenski) prevod povzetka, sicer bo za to poskrbelo uredništvo.

7. V besedilu se po možnosti držimo naslednjih poglavij:

1. Uvod.
2. Pregled dosedanjih objav.
3. Materiali in metode (Dokazni postopek).
4. Rezultati.
5. Razprava ali diskusija.
6. Zaključek (Sklepi).
7. Zahvala - če avtor želi.
8. Priloge - če je potrebno.
9. Literatura (Viri, Bibliografija).
10. Povzetek (Summary).
11. Izvleček.
12. Ključne besede (neobvezno).

8. Ločimo **vsebinske** in **bibliografske** *opombe.* Vsebinske opombe besedilo še podrobneje razlagajo ali pojasnjujejo, postavimo jih *pod črto.* Z bibliografsko opombo pa mislimo na citat - torej sklicevanje na točno določeni del besedila iz neke druge publikacije (navedemo tudi točno stran, kjer je citat objavljen) ali na publikacijo (članek) kot celoto (točne strani, kjer smo besedilo prevzeli, ne navajamo).

Bibliografsko opombo sestavljajo naslednji podatki:

Avtor, leto izida in - le če citiramo točno določeni del besedila - tudi navedba strani.

Celotni bibliografski podatki citiranih in uporabljenih virov so navedeni v poglavju *Literatura* (Viri, Bibliografija).

Primer citata med besedilom:

(Grafenauer, 1993, 11).

Primer navajanja vira kot celote, brez citiranja: (Grafenauer, 1993).

Popolni podatki o tem viru v poglavju Literatura pa se glasijo:

Grafenauer, B. (1993): Miti o "Istri" in resnica istrskega polotoka. V: Acta Histriae I. Koper, Zgodovinsko društvo za južno Primorsko, 9-52.

Če citiramo *več del istega avtorja iz istega leta*, poleg priimka in kratice imena napišemo še črke po abecednem vrstnem redu, tako da se viri med seboj razlikujejo. Primer:

(Grafenauer, 1993a); (Grafenauer, 1993b).

Bibliografska opomba je lahko tudi del vsebinske opombe in jo zapisujemo na enak način.

Posamezna dela ali navedbe virov v isti opombi ločimo s podpičjem. Primer:

(Gombač, 1996; Grafenauer, 1993b).

9. Pri **citiranju arhivskih virov** navedemo najprej arhiv, nato ime fonda ali zbirke in signaturo. V članku navajamo kratico arhivskega vira v oklepaju med besedilom. Kratico pa razložimo v poglavju o virih na koncu prispevka.

Primer navajanja arhivskega vira v oklepaju med besedilom: (PAK. RAG, 1)

Primer navajanja arhivskega vira v poglavju o virih: PAK. RAG - Pokrajinski arhiv Koper, Rodbinski arhiv Gravisi, a. e. (arhivska enota) 1.

Podobno poskušamo ravnati pri uporabi časopisnih virov.

10. Poglavje o literaturi in virih je obvezno. Bibliografske podatke navajamo takole:

- Opis zaključene publikacije kot celote - knjige:

Avtor (leto izida): Naslov. Zbirka. Kraj, Založba. Npr.:

Verginella, M., Volk, A., Colja, K. (1995): Ljudje v vojni. Druga svetovna vojna v Trstu in na Primorskem. Knjižnica Annales 9. Koper, Zgodovinsko društvo za južno Primorsko.

V zgornjem primeru, kjer je *avtorjev več kot dva*, je korekten tudi citat:

(Verginella et al., 1995)

Če navajamo določeni del iz zaključene publikacije, zgornjemu opisu dodamo še številke strani, od koder smo navedbo prevzeli.

- Opis prispevka v **zaključeni publikaciji** - npr. prispevka v zborniku:

Avtor (leto izida): Naslov prispevka. V: Avtor knjige: Naslov knjige. Izdaja. Kraj, Založba, strani od-do. Primer:

Verginella, M. (1995): Poraženi zmagovalci. Slovenska pričevanja o osvobodilnem gibanju na Tržaškem. V: Verginella, M. et al.: Ljudje v vojni. Druga svetovna vojna v Trstu in na Primorskem. Knjižnica Annales 9. Koper, Zgodovinsko društvo za južno Primorsko, 13-51.

- Opis članka v **reviji:**

Avtor (leto izida): Naslov članka. Naslov revije, številka. Kraj, Založba, strani od-do. Primer:

Gombač, B. (1996): Osvoboditev Trsta maja 1945. Annales 8/'96. Koper, Zgodovinsko društvo za južno Primorsko - Znanstveno-raziskovalno središče Republike Slovenije Koper, 141-150.

- opis ustnega vira:

Informator (leto izporočila): Ime in priimek informatorja, leto rojstva, vloga, funkcija ali položaj. Način pričevanja. Oblika in kraj nahajanja zapisa. Primer:

Baf, A. (1998): Alojzije Baf, r. 1930, župnik v Vižinadi. Ustno izporočilo. Magnetofonski zapis pri avtorju.

- opis vira iz internetnih spletnih strani:

www. home page ustanove (leto-mesec izpisa): celoten naslov podstrani. Primer:

www.zrs-kp.si (2000-07):
http://www.slo-istra.com/koper/zrs/zrs.html

Članki so razvrščeni po abecednem redu priimkov avtorjev ter po letu izdaje, v primeru da gre za več citatov istega-istih avtorjev.

11. Tiskarski znaki *za poudarke naj bodo:*
podčrtano za **polkrepko,**
valovito podčrtano za *ležeče.*
Računalniški zapis naj vključuje ustrezne oznake za bold in *italics.*

12. Kratice v besedilu moramo razrešiti v oklepaju, ko se prvič pojavijo. Članku lahko dodamo tudi seznam uporabljenih kratic.

13. Pri **ocenah publikacij** navedemo v naslovu prispevka avtorja publikacije, naslov, kraj, založbo, leto izida in število strani (oziroma ustrezen opis iz točke 10).

14. Prvi odtis prispevkov uredništvo pošlje avtorjem v **korekturo.** Avtorji so dolžni popravljeno gradivo vrniti v treh (3) dneh. Besedilo popravljamo s korekturnimi znamenji, ki jih najdemo na koncu Slovenskega pravopisa (1962), Ljubljana, ali v: Slovenski pravopis 1. Pravila (1990). Ljubljana, SAZU-DZS, 13-14.

Širjenje obsega besedila ob korekturah ni dovoljeno. Druge korekture opravi uredništvo.

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2. Articles (papers) written in Slovene, Italian, Croatian and English languages will be accepted. The Editorial Board reserves the right to have them linguistically revised and corrected.

3. Articles should be written on max. 24 pages with double spacing and on one side of the sheet only. On the left side of each page, a 3-4 cm wide margin is to be left. Original photographs, drawings and tables are welcomed, as well as diskettes containing the texts, together with reference to the programme used.

4. Title page of typescript is to include title and subtitle of the article (paper), author's name, any (academic) titles and name of institution by which employed or personal address with eventual E-mail address.

Articles are arranged in the following eight **categories:**

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Review articles bearing the character of original works. These are critical and detailed reviews of literature from various interesting fields of research.

Preliminary communication and Materials also bearing the character of original works.

Professional papers presenting results obtained through research. They too will be reviewed, and authors oblige themselves not to publish them elsewhere.

Reports include short scientific information on integral research work or a short description of scientific or specialist books or meetings of experts. Such articles are not to exceed 5 pages.

Youth research compositions are to be presented in the same was as research works.

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Notices include news from various associations and should not exceed 1 page.

5. Articles should include both **summary** and **abstract.**

Abstract is the shorter of the two (with up to 10 lines) and does not include, in contrast to summary (with up to 30 lines), explanatory comments and recommendations.

Abstract is to contain a short description of the purpose and methods of the work and its results. Author should also state why the work has been carried out and why a document has been written about it. References to the already published material are made only if this is the main purpose of the work. Methods: if necessary, work methods and techniques are to be briefly described (new techniques are to be stated only if differing from the already known ones). If no experimental or practical work is described, sources of information are to be given. Results and conclusions may be incorporated. Findings are to be presented as briefly as possible.

At the beginning of summary the essential points of the carried out work are to be presented. Sentences should be concise and not too long. The text is to be written in the third person; verbs may be used in impersonal form only exceptionally. The not so well known abbreviations are to be avoided. Summary is to retain the basic information from the main part of the text, and should not contain anything that does not appear in the main text itself.

6. Authors are obliged to define and state **key words** (below abstract) in their articles. **English (or Slovene) translation** of key words, texts accompanying figures and tables are welcomed, as well as English (or Slovene) translation of abstracts; if this is not convenient, the Board of Editors will provide for it.

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4. Results
5. Discussion
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Example of source quotation as a whole, with no citation: (Sommerville, 1995).

The entire data of this source are to be stated in the references and sources chapter as follows:

Sommerville, M. R. (1995): Sex and Subjection. Attitudes to Women in Early-Modern Society. London-New York-Sydney-Auckland, Arnold.

If a number of works *by the same author from the same year* are quoted, letters in alphabetical order are to be stated apart from the author's surname and abbreviation of his first name, in order that the sources are clearly divided between each other. Example:

(Sommerville, 1986a); (Sommerville, 1986b).

Bibliographical note can also be a part of the note referring to the contents and is to be written in the same way, i.e. in brackets within the note referring to the contents.

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Review sources are to be stated in the same way.

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(Matthews et al., 1990, 35)

If a specific part from an integral publication is quoted, the page numbers from which the quotation has been taken are to be added to the above description.

- Description of the **article (paper) in integral publication** - e.g. text in a collection of scientific papers: Author (year of its publication): Title of the paper. In: Author of the book: Title of the book. Volume - Collection. Place of publication, published by, pages from - to. Example:

Matthews, R., Anderson, D., Chen, R. S., Webb, T. (1990): Global Climate and the Origins of Agriculture. In: Newman, L. F. (ed.): Hunger in History. Food Shortage, Poverty, and Deprivation. Oxford-Cambridge, Blackwell, 27-55.

- Description of **article in certain review:** Author (year of its publication): Title of article. Name of review, its number. Place of publication, published by, pages from - to.

Example:

Sluga, G. (1996): Identity and Revolution: The History of the "Forty Days" of May 1945. Annales 8/'96. Koper, Zgodovinsko društvo za južno Primorsko - Znanstveno-raziskovalno središče Republike Slovenije Koper, 125-140.

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Baf, A. (1998): Alojzije Baf, 1930, priest at Vižinada. Personal communication. Tape recording at author's place.

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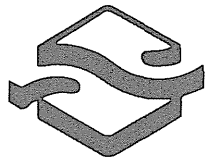

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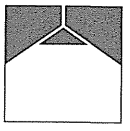

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